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DEVELOPING SUSTAINABLE SMART CITIES TO IMPROVE CITIZEN'S QUALITY OF LIFE AND WELL-BEING

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In the wake of urbanization and environmental challenges, cities nowadays face multiple issues related to uncontrolled urban growth, insufficient public infrastructure, and inadequate citizen participation in the management of public affairs. Sustainable urban development cannot be achieved without addressing these challenges, necessitating a paradigm shift in urban space management. Therefore, urban development needs to shift traditional concepts and focus on incorporating smart and environmentally friendly practices that allow cities to adapt and implement intelligent solutions to meet the needs of their citizens while continuing to protect the environment.

To achieve sustainability, cities should prioritize a balance between economic activity, population growth, urban infrastructure development, and urbanization. Promoting sustainability in urban social, economic, and ecological domains requires the inclusion of technology advancement, supported by people's participation, into urban planning policies and practices through smart city development. Smart cities are gaining recognition as transformative urban environments that leverage technology and data to enhance the quality of life for citizens. While the concept primarily focuses on efficiency, sustainability, and connectivity, the profound impact on citizens' happiness and overall well-being cannot be understated.

The concept of a smart city should be a citizen-centric approach that places the well-being and happiness of citizens at its core. Innovative technologies and data-driven solutions can allow cities to meet the specific needs of their inhabitants. From efficient transportation systems and accessible healthcare to smart governance and inclusive public spaces, citizen-centric smart cities foster a sense of belonging and empowerment.

Smart cities hold immense potential to improve the citizens' quality of life. The seamless integration of advanced technology into urban infrastructures allows decision-making to optimize resource allocation, provide public safety, and offer convenient services for the people. For example, smart utilities such as efficient energy management and automated waste disposal can contribute to a cleaner and more sustainable environment, positively impacting physical and mental well-being. Moreover, smart healthcare systems can offer personalized and timely medical services, ensuring better health outcomes for citizens. In addition, smart cities can improve citizens' access to real-time information, collaboration platforms, and engagement with fellow community members. Digital platforms and smart urban design can further boost citizens' engagement in decision-making processes, fostering a sense of community and public participation.

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Subsequently, smart cities inherently promote sustainability by optimizing resource management, reducing energy consumption, and endorsing eco-friendly practices. Cities like Singapore and Amsterdam have implemented smart infrastructure and utilize renewable energy, such as water-based and wind-based technologies, to minimize their environmental footprint while ensuring a resilient future by implementing smart infrastructure and renewable energy sources. The inclusion of green spaces, pedestrian-friendly zones, and efficient public transportation systems may contribute to citizens' physical and mental well-being, fostering vibrant and sustainable communities.

Despite the importance of focusing on the positive aspects of smart cities, it is also essential to be aware of any potential issues. Concerns regarding data privacy, the technological gap, and the prospect that technology will exacerbate social differences must be addressed in advance to ensure the sustainability of smart city development.

Therefore, we believe that the potential of smart cities extends beyond technological advancements and environmental benefits. It also lies in smart city capability to improve citizens' quality of life and well-being. By placing individuals at the center of urban development, smart cities can provide efficient and accountable services, foster a sense of community, and enhance the overall quality of life. Policymakers, urban planners, and stakeholders must prioritize citizen-centric approaches and ensure that the benefits of smart cities are accessible to all to promote inclusion and equality. Then and only then can we establish cities that value the happiness and well-being of their citizens.

Promoting Research on Planning, Technology, and Management of Urban Development

Research on the planning, technology, and management of urban development plays a crucial role in advancing knowledge and generating innovative approaches to enhance the well-being of human beings in cities. In this edition, the CSID Journal of Infrastructure Development proudly presents a collection of nine papers that delve into this research area, offering valuable insights and perspectives.

The first paper, written by A.C. Haruna, S. Mukiibi, and A. Nnaggenda-Musana, examines the gender analysis of sustainable housing choices for rental household heads in Abuja Municipal Council, Nigeria. This study identifies the important economic, social, and environmental housing decision determinants using cross-sectional survey and questionnaire. The results highlight the importance of household income level, rental cost relative to income, housing characteristics, access to amenities, and environmental factors in deciding housing affordability.

The second paper, written by A. Wardhana, M. Ramayuda, F.F. Muhammad, A.P. Nariswari, S.D.C. Arifin, G.A. Wicaksono, D.R. Dianafi, M.I.R.S. Psf, discusses the Janjang Wulung Village community in Indonesia and its economic resilience post COVID-19 through creative economic village planning. The study examines the village's physical and non-physical circumstances, including pandemic effects on agriculture and livestock.

The third paper, written by B.M. Adeleye, K. Ssemwogerere, P.I. Mukwaya, A.T. Kiggundu, F. Omolo-Okalebo, and L.M. Kayondo, uses remote sensing and GIS data to assess urban transformation in Suleja Local Government Area, Niger State, Nigeria. The study examinethe s pattern of urban change from 1987 to 2019 and finds its key factors to provide insight into regional urban management and planning.

The fourth paper, written by A. Urrohmah, E. Ellisa, and A.H. Fuad, examines the impact of motorcycles on the permeability of Jakarta, a rapidly urbanizing city in Southeast Asia. It highlights the importance of motorcycles in enhancing mobility and accessibility in the city, particularly in areas with long distances and narrow streets. The research combines field

observations, online observations, and interviews with key actors to provide a comprehensive understanding of the role of motorcycles in transforming the layout of Jakarta's outskirts.

The fifth paper, written by L. Qu, G. Xia, and C. Bao, discusses the construction and preliminary application of the Carbon-Based Spatial Governance Performance Evaluation System for evaluating spatial governance performance by considering carbon-related indicators and providing insights into social and economic activities, energy consumption, and carbon emissions. The paper uses the system in Zhejiang Province to make spatial governance policy suggestions.

The sixth paper, written by M.A. Berawi, S. Dikun, R. Bintoro, M. Sari, and S.I. Susilowati, evaluates the use of insurance funds as a financing source for infrastructure development in Indonesia. It identifies insurance funds' main risks in infrastructure investment through consultation with experts and regulators. The study utilizes the analytical hierarchical process (AHP) method to assess the risks and prioritize the role and responsibilities of the government and private sectors in infrastructure investment.

The seventh paper, written by O. Luova, analyzes sustainable mobility strategies in Graz, Austria, and Hangzhou, China, from the late 1980s to 2020. It compares public transit and non-motorized mobility initiatives to sustainable, low-carbon, and smart traffic policies. The paper examines the growth paths of these two cities, identifies parallels and contrasts, and offers sustainable urban mobility research topics.

The eighth paper, written by O. Jakonen, addresses people-centric and inclusive smart city development. It discusses the necessity of defining key concepts like people-centric, effective participation, and inclusion. The study argues that people-centric smart cities should embrace participatory design facilitated by digital tools, recognize the complexities of specific places, and ensure that different demographics can benefit from smart initiatives in their everyday lives.

The ninth paper, written by T. Patriot, investigates the effectiveness of integrated traffic management in reducing driving speed on arterial roads. It utilizes an experimental approach to evaluate the impact of traffic regulations, such as speed monitoring with radar and motorcycle patrols, on vehicle speed and compliance with speed limits. The results suggest that these methods can reduce driving speed and improve road safety.

We hope this edition may convey new insight and knowledge that benefit our readers. We welcome any comments or inquiries that you may have concerning the direction and the content of this journal. We invite you to join our venture by sending your work for future consideration.

Warmest regards from the Editorial Office,

Prof. Mohammed Ali Berawi
Editor-in-Chief

Dr. Mustika Sari
Managing Editor

Perdana Miraj
Managing Editor

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GENDER ANALYSIS OF SUSTAINABLE HOUSING CHOICES OF RENTAL HOUSEHOLD HEADS IN ABUJA MUNICIPAL COUNCIL, NIGERIA

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ABSTRACT

Households' income and other concerns constitute important sustainable housing choices factors that play vital roles in influencing rental housing affordability decisions. The study determined both male and female households can make economic, social, and environmental housing choices to meet their affordable rental needs. A cross-sectional survey was conducted, and a questionnaire was administered to a sample of 285 households obtained from a random sampling of 450 households living in private rental housing in Trademore estate in the Lugbe district of Abuja. Among the 285 households, 226 were household heads representing 79.3% of the respondents' households. The household heads consist of 171 and 55 males and females, respectively. Data in sustainable housing choices of household heads, analyzed by principal components analysis method of exploratory factor analysis and mean rating (MR), frequencies, percentages in SPSS 25. Results indicated the sustainable economic housing choices drivers that household heads can consider for household rental affordability are Employment and Housing Prices and income and expenditure. Whereas the sustainable social housing choices drivers for household heads' rental affordability consideration were housing characteristics and access or availability of dare-care and mall, the sustainable environmental choices drivers were waste and pollution, energy efficiency, materials, and noise pollution. The study recommended that households consider the economic, social, and ecological factors for sustainable housing choices when deciding on rental accommodation to meet their rental needs. It is also advocated that both government and private investors and developers of rental housing apply the study findings to provide sustainable and affordable rentals for their clients.

Keywords: Rental affordability; Sustainable housing choices; Households heads; Gender

1. INTRODUCTION

Households' income and other considerations constitute important sustainable housing choices factors that play vital roles in influencing households' rental housing affordability decisions. Scholars identified housing choices as decisions taken by households when considering the choice of house, and these decisions depend, among others, on house type, tenure, neighborhood, and location as well as housing size (Mulder, 1996; Ghazali et al., 2019; Adabre & Chan, 2019; Chan & Adabre, 2019). The rental housing choice factors are influenced by economic, social, and environmental elements, which form the sustainable aspects of rental housing choices.

Integrating sustainability into housing choice is referred to as sustainable housing choice (SHC) or sustainable, affordable housing choice (SAHC) according to Ikenna & Sebnem (2019) and define sustainable housing:

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> "…as one that is built with sustainability requirement that satisfies the current generation's demand and needs without compromising future generations' ability to meet their housing demand and needs. SAHC is the combined ability to select and choose a house for renting at a minimum price in a safe environment that facilitates healthy living."

To understand the environmental housing decision determinants, this study conducted gender analysis of sustainable housing choices for rental household heads, particularly in Abuja Municipal Council, Nigeria.

2. LITERATURE STUDY

According to Zinas & Jusan (2012), choices are assumed to reflect the decision for preferences in housing. In contrast, Ham (2012) attributed choice to being able to choose a preferred option from a set of distinctive alternatives. Housing choices depend on the characteristics of the individuals and their households. According to Olanrewaju & Woon (2017) and also cited by Ikenna & Sebnem (2019), the likely generating imbalance between demand and supply of affordable housing is the failure to reconcile households' choices and supply. It means inadequate rental housing supply can limit housing choices for rent by households. Housing choice is a topical issue of interest amongst researchers of diverse disciplines studied from different theoretical perspectives. Economists focus on housing prices and how housing costs determine the choice between owning and renting. Sociologists study the housing choices which individual households make and examine housing distribution in a given population. Geographers focus on socio-economic and demographic aspects, the dwelling, and neighborhood features influencing housing choices (Coolen et al., 2002; Tao et al., 2015; Ikenne & Sebnem, 2019). It reveals that households can choose housing that appeals to them based on different choices they have to consider and make decisions on. Jean-Claude (2009) argues that choices result from a decision-making process involving multiple sets of alternatives. Therefore, the housing choices that households can make are usually based on access to information on available rental houses and the ability to make subjective estimations of alternatives (Qu & Hasselaar, 2011).

In an exploratory study of the severity of factors influencing sustainable housing choice among low and medium-income households, Ikenna and Sebnem (2019) observed that integrating sustainability into the concept of affordable housing choices is a strategy that requires environmental and social factors to be considered, which are routinely neglected in the housing choice literature. Thus, this study has integrated sustainability into housing choices factors whereby economic, social, and environmental factors were considered sustainable housing choices (SHCs) factors and examined the perception of male and female rental household heads on the SHCs for their rental housing affordability. Rental housing affordability has been viewed as the ability of households in rental tenure to meet their housing costs, expressed as a ratio of income to rental price not more than 30% (Okey, 2007). Therefore, the study has assisted in achieving the following objectives: to identify the factors that drive sustainable housing choices of rental household heads and establish the severity of the factors by ranking the factors based on the rental households' sustainable housing choices perception. Consequently, answers were sought to the following questions: What are the drivers of sustainable housing choices of households' rental affordability? How important are each of the sustainable housing choices factors to the household's decision for rental affordability?

This study looked at the sustainable housing choices of rental household heads in the study area, Trademore Estate. The household head was regarded as the person/member whom the household members recognized as such. They are usually an adult and is the one who bears the major responsibility of training the household members and making decisions on their behalf. The head

can be a male or female (National Bureau of Statistics, 2007). The study considered the sustainable housing choices decisions by household heads of different gender taken from economic, social, and environmental considerations. The research contributed to filling the gap in sustainable housing choices for rental household heads' affordability.

3. METHOD AND ANALYSIS

Data on Sustainable Housing Choices (SHC) of 226 rental household heads who constituted the respondents for the study were collected from residents in Trademore estate Abuja. The household heads were obtained from 285 rental households sampled by simple random techniques. A semi-structured questionnaire survey was used in the collection of data on SHC. Face-to-face interviews were also conducted with three (3) male and three (3) female household heads tenants and obtained more information on the households' rental experiences and choices. The female respondents interviewed were given the following pseudo names for confidentiality to conceal their identity: Abella, Dora, and Favour. The quasi-names given to the male respondents were Broda, Chris, and Eris. The SHCs, classified into three sustainable categories: economic, social, and environmental, were identified and obtained through literature and questionnaires administered in the pilot survey based on the respondents' perceptions. Data were analyzed utilizing a severity index using mean rating and principal component analysis (PCA).

3.1. Mean Rating Ranking

The severity of factors influencing sustainable housing choices was calculated and ranked using a mean rating score. The ranking was done according to gender and both gender combination. The severity levels of the SHC factors influencing rental households' affordability were distributed in 5 Linkert scales. This severity index of each SHC factor revealed its critical importance. Descriptive statistic of mean score rating was used. The mean rating (MR) score is commonly used to determine the relative importance of a data set (Field, 2009). It was used to identify the top-ranked variables deemed appropriate for large samples (Norman, 2010). Therefore, the mean score rating was used to rank the factors of SHCs. The data were analyzed by the computation of mean ratings (MR) of each variable using five (5) point Linkert scale with scale values ranging from 1 to 5 given to each factor by the respondent (1 number = No Comments responses; 2 number = Not Severe responses; 3 number = Somehow Severe; 4 number = Severe responses; and 5 number = Very Severe response).

The total number of respondents (TR) rating each variable was obtained and used to calculate the percentage of respondents associating a particular rating point (Rp). The mean rating (MR) was calculated as the summation of the products of each rating point (Rp) and the corresponding percentage response to it (R%) out of the total number of responses (TR) involved in rating a particular variable as shown in Equation 1:

$$MR = \sum_{j=1}^{5}(Rpi \cdot Ri\%) \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots (1)$$

where: Rpi = rating point ranging from 1 to 5

Ri = percentage response to rating point i

3.2. Principal Component Analysis

Exploratory factor analysis (EFA) using Principal Component Analysis (PCA) method was used to analyze the economic, environmental, and social factors of the SHC using the IBM SPSS Statistics 25 package. The PCA was used to extract the most severe factors in sustainable housing choices in the study area. The operational equation of the factor analysis is given by:

$$P_1 = a_{11}X_1 + a_{12}X_2 + \cdots + a_{1k}X_k$$
$$a??a??a??a??a?? \qquad \ldots\ldots\ldots\ldots\ldots\ldots (2)$$
$$P_k = a_{k1}X_1 + a_{k2}X_2 + \ldots + a_{kk}X_k$$

Equation (2) is the mathematical basis for analysis. The X's in the equation are the component scores of Pi's, called the principal components. The aij.'s's are the factor loading worked out in such a way that the extracted components satisfy two conditions: (i) the principal component is uncorrelated (orthogonal), and (ii) the first principal component (P_1) has the maximum variance, the second principal component (P_2) has the next maximum variance and so on. The X's confidence level for all inferential statistics was 95%, which implies a 0.05 level of significance.

The key concept of the Principal Component Method of Factor Analysis (PCA) is that multiple observed variables with similar response patterns are grouped because they are all associated with a latent (i.e., not directly measured) variable. PCA is a veritable tool for investigating variable relationships for complex concepts, as is the case of subjects such as sustainable housing choices for the rental affordability of household heads. It described variability among observed, correlated variables in terms of a potentially lower number of unobserved variables called factor (which are given a common name). Using the PCA, top severe SHC factors were narrowed down to the minimum. The principal component method of factor analysis was used to extract the most severe SHC factors in the study area.

Before conducting factor analysis, the Kaiser-Meyer-Olkin (KMO) index and Bartlett's test of sphericity, measures of sampling adequacy, were used to evaluate the suitability of the collected data for factor analysis (Williams et al., 2010). Data with a KMO value exceeding the minimum value of 0.5 were acceptable and within the acceptable range (Tabachnick et al., 2007; Field, 2013). Bartlett's's tests indicate statistical significance with a value less than the maximum of 0.05. These tests show the suitability of the data for factor analysis. To determine the number of important underlying factors (drivers), PCA was carried out on the SHCs measures with varim'x' as the factor rotation method (Corner, 2009). As an outcome of factor analysis, eigenvalues were utilized to signal the variance of each underlying factor from the total variance. Factors with an Eigenvalue of 1.0 were retained (Nunnally, 1994; Brown, 2001). Variables with a factor loading below 0.5 were excluded to reduce cross-loading and clarify outcomes interpretation of outcomes (Lingard et al., 2000; Akinade et al., 2017; Hadi et al., 2016).

4. RESULTS AND DISCUSSION

The results and discussion of the findings based on the exploratory factors analysis of SHCs and the three (3) dimensional spheres of rental housing choices of household heads: economic, social, and environmental, are presented in this section.

4.1. Sustainable Housing Choices of Household Heads

The sustainable economic factors (SECF) had Household income level (SECF1) and Rental cost concerning income (SECF3) topped in the first and second position, respectively, as the most severe economic SHC factors indicated in Table 1. Male and Female HHHs had household income (SECF1) as the topmost severe economic SHC factor. It suggests that both households were challenged by income level as corroborated by gender housing demand by Skaburskis (1997) that renters are challenged greater in household income and more confronted with housing burden. Therefore, the rent-to-income ratio appeal to households' common-sense and experiences

for their rental affordability (Stephen & Hoskara, 2019). In summary, EFA on economic factors grouped the SECF into three and rated accordingly: Employment and Price, Income and Expenditure, and Transport Cost and Banking. It confirmed the study by Li et al. (2018), which linked housing cost and cost of transportation to a household's housing affordability.

For the sustainable social factors (SSOF), Availability of water supply (SSOF25) and availability of power supply (Electricity) (SSOF24) topped in the first and second position, respectively, as the most severe social SHC factors. Also, both Male and Female HHHs indicated water supply availability (SSOF25) as the first top-ranked social SHC factor, as presented in Table 2. This demonstrated Hoda (2007)'s assertion that gender housing preferences by households are influenced by their expectations. The provision and availability of water supply as well as power in rental housing for domestic use do influence households' choices for such rental and cannot be overemphasized. Water and power services are usually provided to make buildings generally and houses, particularly, liveable and comfortable for occupants. In summary, EFA on social factors grouped the SSOF into four drivers and rated accordingly: Housing Characteristics, daycare and Mall, Road Access and Transportation, and Education and Location.

For the Sustainable Environmental Factors (SEVF) shown in Table 3, Efficient waste management (SEVF2), Less/Absence of noise pollution (SEVF6) topped in the first and second positions, respectively, as the most severe environmental SHC factors. However, while Male HHHs indicated SEVF2, Female HHHs showed SEVF6 as the topmost environmental SHC factor. This finding implies that households place important value on non-economic factors such as Efficient waste management (SEVF2) and Less/Absence of noise pollution (SEVF6) in the environment are equally important factors driving households' rental housing choices. This affirmation is in line with Oguntoyinbo (2012) as well as Stephen & Hoskara, 2019), who argued that poor waste management in the housing environment is among the factors of Sustainable Housing Choice. The EFA of environmental factors grouped the SEVF into three drivers and rated accordingly: Waste and Pollution, Energy Efficiency, and Materials and Noise Pollution.

Table 1 Household Heads Sustainable Housing Choices SECF Ranking

Sustainable Economic Factors (SECF)	**Female N=55**		**Male N=171**		**Overall Score Rank**	
	MR	**Rank**	**MR**	**Rank**	**MR**	**Rank**
Household income level **(SECF1)**	4.018	1	4.187	1	4.146	1
Available mortgages and interest rates **(SECF2)**	3.582	5	3.152	7	3.257	6
Rental cost in relation to income **(SECF3)**	3.945	3	4.029	2	4.009	2
Energy bill in relation to income **(SECF4)**	3.491	6	3.567	4	3.549	5
Water bill in relation to income* **(SECF5)**	3.091	9	2.971	10	3.000	10
Employment opportunities **(SECF6)**	3.982	2	3.579	3	3.677	3
House price in relation to income **(SECF7)**	3.709	4	3.561	5	3.597	4
Taxation and subsidy influences **(SECF8)**	2.982	10	3.088	9	3.062	9
Rent tenure security **(SECF9)**	3.182	8	3.211	6	3.204	7
Transportation cost in relation to income **(SECF10)**	3.291	7	3.135	8	3.173	8
Availability of banking services* **(SECF11)**	2.491	11	2.626	11	2.593	11

*Added by responding MR: Mean Rating Source: Survey 2021

Table 2 Household Heads Sustainable Housing Choices SSOF Ranking

Sustainable Social Factors (SSOF)	Female N=55		Male N=171		Overall score (Rank)	
	MR	Rank	MR	Rank	MR	Rank
Accessibility **(SSOF1)**	3.109	6	3.175	9	3.159	6
Building types (flats, detached/semi-detached bungalow) **(SSOF2)**	3.109	6	3.211	7	3.186	5
Housing quality/Adequacy (meeting decent home standards) **(SSOF3)**	3.145	5	3.222	5	3.204	4
Safety/Security (reduced incidence of crime) **(SSOF4)**	3.218	4	3.275	3	3.261	3
Minimized social segregation **(SSOF5)**	2.691	19	2.766	22	2.748	23
Car parking spaces **(SSOF6)**	2.800	15	2.877	19	2.858	19
Presence of lift or elevator **(SSOF7)**	2.345	26	2.029	26	2.106	26
Suitability/Type of architectural design **(SSOF8)**	2.436	25	2.368	25	2.385	25
Access to leisure facilities (Parks, green open spaces) **(SSOF9)**	3.400	2	3.012	14	3.106	9
Effective maintenance and management of property **(SSOF10)**	2.800	15	3.181	8	3.088	11
Household size **(SSOF11)**	2.618	22	2.959	16	2.876	18
Housing unit size **(SSOF12)**	2.709	17	2.936	17	2.881	17
Clean and attractive **(SSOF13)**	2.927	11	3.158	10	3.102	10
Number of bedrooms **(SSOF14)**	2.818	14	3.222	5	3.124	7
Number of bathrooms **(SSOF15)**	2.964	10	2.971	15	2.969	14
Housing location (city, urban, etc.) **(SSOF16)**	2.873	13	3.023	12	2.987	13
Access to sports facilities **(SSOF17)**	2.655	20	2.830	21	2.788	21
Access to health facilities **(SSOF18)**	2.927	11	3.047	11	3.018	12
Access to religious places **(SSOF19)**	3.073	8	2.690	24	2.783	22
Access to educational centers **(SSOF20)**	2.655	20	3.023	12	2.934	15
Access to child daycare centers **(SSOF21)**	3.036	9	2.836	20	2.885	16
Access to/location of the shopping mall **(SSOF22)**	2.491	24	2.725	23	2.668	24
Availability of public transportation **(SSOF23)**	2.509	23	2.930	18	2.827	20
Availability of power supply **(SSOF24)**	3.400	2	3.316	2	3.336	2
Availability of water supply **(SSOF25)**	3.527	1	3.795	1	3.730	1
Major and minor access road network **(SSOF26)**	2.709	17	3.251	4	3.119	8

MR: Mean Rating Source: Survey 2021

Table 3 Household Heads Sustainable Housing Choices SEVF Ranking

Sustainable Environmental Factors	Female N=55		Male N=171		Overall Score Rank	
	MR	Rank	MR	Rank	MR	Rank
Air quality **(SEVF1)**	2.836	5	2.889	4	2.876	4
Efficient waste management **(SEVF2)**	3.109	2	3.269	1	3.230	1
Use of appropriate materials **(SEVF3)**	2.927	4	2.784	7	2.819	5
Thermal comfort (heating/cooling system) **(SEVF4)**	2.636	7	3.006	2	2.916	3
Energy access **(SEVF5)**	2.509	8	2.854	5	2.770	8
Less/Absence of noise pollution **(SEVF6)**	3.145	1	2.947	3	2.996	2
Absence of water pollution **(SEVF7)**	2.836	5	2.789	6	2.801	7
Lighting quality, e.g., Daylighting **(SEVF8)**	3.036	3	2.737	8	2.810	6

MR: Mean Rating Source: Survey 2021

4.2. Exploratory Factor Analysis of the Suitability of Sustainable Economic Factors

Exploratory factor analysis (EFA) is conducted to reduce the number of items from large to small to provide construct validity evidence (Field, 2013). EFA was carried out using IBM SPSS25 on eleven (11) sustainable economic factors (SECF) variables of sustainable housing choices (SHC). The factor analysis was carried out on the eleven (11) SECF factors obtained from the responses of 226 household heads.

The 11 factors were reduced into eight (8) SECF factor items, as shown in the communalities of factors for household heads in Table 4. The factors reduction was carried out by setting the absolute value for extraction at 0.5 value. At initial extraction, any item (factor) with an extraction value less than the 0.5 absolute value was deleted to obtain communalities. All items were loaded with absolute values greater than 0.5 extraction value in the communalities of factors. The communalities of the factors were achieved after four (4) iterations. Total variance analysis, as shown in Table 5, indicated a cumulative variance of 59.8% by three extracted components. Table 6 shows that the eight (8) reduced items of SECF were loaded and factored into three (3) components, with component 1 having four (4) items, component 2 having two (2) items, and component 3 having two (2) items after rotation converged at four (4) iterations using principal component analysis (PCA) method of extraction. The three components extracted accounted for 59.8% total (cumulative) variance, as indicated in Table 6. The three components were coded as Income and Expenditure (IE) for Component 1, with 26.5% variance; Employment and Price (EP) for Component 2, with 17.9% variance; and Transport and Banking (TB) for Component 3, with 15.4% variance. The items under Income and Expenditure (IE) included: Energy bill in relation to income **(SECF4)**, Household income level **(SECF1)**, Rental cost in relation to income **(SECF3)**, and Water bill in relation to income* **(SECF5)**. Items under Employment and Price (EP) comprised Employment opportunities **(SECF6)** and House price in relation to income **(SECF7)**. At the same time, Transport Cost and Banking (TB) contained the following items Availability of banking services* **(SECF11)** and Transportation cost in relation to income **(SECF10)**.

Table 6 also shows the Kaiser-Meyer-Olkin (KMO) value which measures sampling adequacy as 0.6 is more than the 0.5 minimum recommended by Kaiser (1974) and is equal to Pallant (2013) recommendation of a KMO value of 0.6 and above. Thus, data sampling adequacy is sufficient. Hence, the SECF sample is acceptable. Bartlett's Test of Sphericity showed the significance of SECF factors with 0.000 significant value. The value of Bartlett's test of sphericity indicates that the correlation matrix is not an identity matrix. None of the Average Variance Extracted (AVE) values for each component were below the minimum acceptable 0.5 value. All the composite reliability (CR) values were 0.7 and above.

Table 4 SECF Communalities of Factors

Communalities[a]		
	Initial	**Extraction**
SECF1	1.000	.520
SECF3	1.000	.573
SECF6	1.000	.687
SECF7	1.000	.710
SECF10	1.000	.639
SECF11	1.000	.501
SECF4	1.000	.612
SECF5	1.000	.539

Extraction Method: Principal Component Analysis.
[a] Head of Household = Household heads

Table 5 SECF Total Variance Explained[a]

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	2.120	26.504	26.504	2.120	26.504	26.504	1.844	23.044	23.044
2	1.430	17.881	44.385	1.430	17.881	44.385	1.632	20.406	43.450
3	1.231	15.387	59.771	1.231	15.387	59.771	1.306	16.321	59.771
4	.905	11.317	71.088						
5	.813	10.167	81.255						
6	.602	7.531	88.786						
7	.502	6.271	95.057						
8	.395	4.943	100.000						

Extraction Method: Principal Component Analysis.
[a]Head of Household = Household heads

Table 6 SECF Rotated Component Matrix[a,b]

Common Name	Item	Component		
		1	2	3
Income and Expenditure (IE)	SECF4	.718		
	SECF1	.709		
	SECF3	.698		
	SECF5	.558		
Employment and Price (EA)	SECF6		.827	
	SECF7		.798	
Transport Cost and Banking (TB)	SECF10			.795
	SECF11			.688
Eigen Value (*59.771%)*		26.504	17.881	15.387
Average Variance Explained (AVE ≥ 0.5)		0.5	0.7	0.6
Composite Reliability (CR ≥ 0.7)		0.8	0.8	0.7
Kaiser-Meyer-Olkin (KMO) Measure of Sampling Adequacy				0.6
Bartlett's Test of Sphericity		Approx. Chi-Square		246.518
		Df		28
		Sig.		.000

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization.
[a]Head of Household = Household heads
[b]Rotation converged in 4 iterations.

4.3. Exploratory Factor Analysis of the Suitability of Sustainable Social Form

EFA was carried out using IBM SPSS25 on twenty-six (26) sustainable social factors (SSOF) variables of sustainable housing choices (SHC). The factor analysis was carried out on the twenty-six (26) SSOF factors obtained from the responses of 226 household heads. The factors were reduced into ten (10) SSOF factor items as shown in the communalities of factors for household heads in Table 7. The factors reduction was carried by setting the absolute value for extraction at 0.5 value. At initial extraction, any item (factor) with an extraction value less than the 0.5 absolute value is deleted to obtain communalities. All items were loaded with absolute values greater than 0.5 extraction value in the communalities of factors. The communalities of the factors were realized after six (6) iterations. Total variance analysis, as shown in Table 7, indicated a cumulative variance of 72.5% by four extracted components. Twenty-six (26) items or factors of SSOF were reduced into ten (10) items which were loaded and factored into four (4) components, with components 1 and 2 having three (3) items each, while components 3 and 4 having two (2) items each after rotation converged at six (6) iterations using principal component analysis (PCA) method of extraction (See Table 8 and Table 9). The four components extracted accounted for

72.5% total (cumulative) variance, as indicated in Table 9. The four components were coded as Housing Characteristics (HC) for component 1, with 35.0% variance; Education and Location (EL) for Component 2, with 13.9% variance; Daycare and Mall (DM) for Component 3, with 12.4% variance; and Accessibility and Transport (AT) for component 4, with 11.2% variance. The items under Housing Characteristics (HC) included Housing unit size **(SSOF12),** Household size **(SSOF11)**, and Clean and attractive **(SSOF13)**; items under Education and Location (EL) comprised Access to educational centers **(SSOF20)**, Availability of power supply **(SSOF24)**, and Housing location, (city, urban, etc.) **(SSOF16)**; Daycare and Mall (DM) contained the following items Access to child daycare centers **(SSOF21)** and Access to/location of a shopping mall or market **(SSOF22)**; while Road Access and Transportation (RT) contained the following item's Availability of public transportation **(SSOF23)** and Major and minor access road network **(SSOF26)**.

Table 9 also shows the Kaiser-Meyer-Olkin (KMO) value which measures sampling adequacy as 0.6, which is more than the 0.5 minimum recommended by Kaiser (1974) and Pallant (2013), who recommended a KMO of 0.6 and above for sufficient sampling adequacy. Hence, the SSOF sample is acceptable. Bartlett's Test of Sphericity showed the significance of SSOF factors with a 0.000 significant value. None of the Average Variance Extracted (AVE) values for each component were less than the minimum acceptable 0.5 value. All the composite reliability (CR) values were 0.7 and above.

Table 7 SSOF Communalities of Factors

	Communalities[a]	
	Initial	Extraction
SSOF11	1.000	.822
SSOF12	1.000	.739
SSOF13	1.000	.711
SSOF21	1.000	.817
SSOF22	1.000	.724
SSOF20	1.000	.749
SSOF24	1.000	.841
SSOF23	1.000	.708
SSOF26	1.000	.561
SSOF16	1.000	.582

Extraction Method: Principal Component Analysis.
[a]Head of Household = Household heads

Table 8 SSOF Total Variance Explained[a]

Component	**Initial Eigenvalues**			**Extraction Sums of Squared Loadings**			**Rotation Sums of Squared Loadings**		
	Total	**% of Variance**	**Cumulative %**	**Total**	**% of Variance**	**Cumulative %**	**Total**	**% of Variance**	**Cumulative %**
1	3.502	35.016	35.016	3.502	35.016	35.016	2.172	21.717	21.717
2	1.400	13.999	49.015	1.400	13.999	49.015	1.870	18.705	40.422
3	1.236	12.358	61.372	1.236	12.358	61.372	1.762	17.621	58.043
4	1.117	11.172	72.545	1.117	11.172	72.545	1.450	14.502	72.545
5	.701	7.012	79.557						
6	.653	6.533	86.090						
7	.499	4.986	91.076						
8	.362	3.622	94.699						
9	.290	2.895	97.594						
10	.241	2.406	100.000						

Extraction Method: Principal Component Analysis.
[a] Head of Household = Household heads

Table 9 SSOF Rotated Component Matrix[a,b]

Common Name	Item	Component			
		1	2	3	4
Housing Characteristics (HC)	SSOF12	.817			
	SSOF11	.787			
	SSOF13	.768			
Education and Location (EL)	SSOF20		.817		
	SSOF24		.755		
	SSOF16		.667		
Daycare and Mall (DM)	SSOF21			.866	
	SSOF22			.743	
Road Access and Transportation (RT)	SSOF23				.837
	SSOF26				.683
Eigen Value (72.545%)		35.016	13.999	12.358	11.172
Average Variance Explained (AVE ≥ 0.5)		0.6	0.6	0.7	0.6
Composite Reliability (CR ≥ 0.7)		0.8	0.8	0.8	0.7
Kaiser-Meyer-Olkin (KMO) Measure of Sampling Adequacy					0.7
Bartlett's Test of Sphericity		Approx. Chi-Square			716.375
		Df			45
		Sig.			.000

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization.
[a]Head of Household = Household heads
[b]Rotation converged in 6 iterations.

4.4. Exploratory Factor Analysis of the Suitability of Sustainable Environmental Factors

EFA was carried out using IBM SPSS25 on eight (8) sustainable environmental factors (SEVF) variables of sustainable housing choices (SHC). The factor analysis was carried out on the eight (8) SEVF factors obtained from the responses of 226 household heads. The factors were reduced into six (6) SEVF factor items, as shown in the communalities of factors for household heads in Table 10. The factors reduction was carried out by setting the absolute value for extraction at 0.5 value. At initial extraction, any item (factor) with an extraction value less than the 0.5 absolute value is deleted to obtain communalities. All items were loaded with absolute values greater than 0.5 extraction value in the communalities of factors. The communalities of the factors were achieved after four (4) iterations. Total variance analysis, as shown in Table 11, indicated a cumulative variance of 72.8% by three extracted components. Table 12 indicated that the six 6) reduced items of SEVF were loaded and factored into three (3) components which had two (2) items each after rotation converged at four (4) iterations using the principal component analysis (PCA) method of extraction. The three components extracted accounted for 72.8% total (cumulative) variance, as indicated in Table 12. The three components were coded as Waste and Pollution (WP) for Component 1, with 29.3% variance; Energy Efficiency (EE) for Component 2, with 25.7% variance; and Materials and Noise Pollution (MN) for Component 3, with 17.8% variance. The items under Waste and Pollution (WP) included Air quality **(SEVF1)** and Efficient waste management **(SEVF2)**; items under Energy Efficiency (EE) comprised Energy access **(SEVF5)** and Thermal comfort (heating/cooling system) **(SEVF4)**; while Materials and Noise Pollution (MN) contained the following items Use of appropriate materials **(SEVF3)** and Less/Absence of noise pollution **(SEVF6)**.

Table 12 also shows the Kaiser-Meyer-Olkin (KMO) value which measures sampling adequacy as a 0.5 value. It satisfied the 0.5 value minimum Kaiser (1974) recommended for sufficient sampling adequacy. Bartlett's Test of Sphericity showed the significance of SEVF factors with a 0.000 significant value. None of the Average Variance Extracted (AVE) values for each component were below the minimum acceptable 0.5 value. Also, the composite reliability (CR) values were 0.8, above the minimum 0.7 value.

Table 10 Communalities of Factors

Communalities[a]		
	Initial	Extraction
SEVF1	1.000	.753
SEVF2	1.000	.696
SEVF3	1.000	.823
SEVF4	1.000	.657
SEVF5	1.000	.806
SEVF6	1.000	.631

Extraction Method: Principal Component Analysis.
[a]Head of Household = Household heads

Table 11 SEFV Total Variance Explained[a]

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	1.756	29.272	29.272	1.756	29.272	29.272	1.552	25.871	25.871
2	1.540	25.660	54.932	1.540	25.660	54.932	1.515	25.256	51.127
3	1.070	17.840	72.771	1.070	17.840	72.771	1.299	21.644	72.771
4	.645	10.746	83.517						
5	.604	10.062	93.579						
6	.385	6.421	100.000						

Extraction Method: Principal Component Analysis.
[a]Head of Household = Household heads

Table 12 SEVF Rotated Component Matrix[a, b]

Common Name	Item	Component		
		1	2	3
Waste and Pollution (WP)	SEVF1	.848		
	SEVF2	.824		
Energy Efficiency (EE)	SEVF5		.894	
	SEVF4		.774	
Materials and Noise Pollution (MN)	SEVF3			.890
	SEVF6			.668
Eigen Value *(72.771%)*		29.272	25.660	17.840
Average Variance Explained (AVE ≥ 0.5)		0.7	0.7	0.6
Composite Reliability (CR ≥ 0.7)		0.8	0.8	0.8
Kaiser-Meyer-Olkin (KMO) Measure of Sampling Adequacy				0.5
Bartlett's Test of Sphericity		Approx. Chi-Square		185.434
		Df		15
		Sig.		.000

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization.
[a]Head of Household = Household heads
[b]Rotation converged in 4 iterations.

Figure 1 summarizes the framework of drivers of social, environmental, and economic sustainable housing choices for rental household heads. Forty-five (45) SHC drivers or factors were extracted using principal component analysis of exploratory factor analysis and reduced to 24 items which were then condensed to ten (10) main groups: SECF were ultimately grouped into three main drivers (i.e., Employment and Price, Income and Expenditure, Transport Cost and Banking); SSOF were grouped into four drivers (Housing Characteristics, Education and Location, Daycare and Mall, Road Access and Transportation); and SEVF grouped into three drivers (Waste and Pollution, Energy Efficiency, Materials, and Noise Pollution).

Figure 1 also indicates each Sustainable Housing Choices grouped component's average mean (AM) rating value. Each of the component SHC was rated and ranked using the AM values. Results show Employment and Price (EP) with a 3.35 average mean and Income and Expenditure (IE) with a 2.91 average mean rated first and second positions for SHC Sustainable Economic Factors. Housing Characteristics (HC) and Daycare and Mall (DM), with an average mean of 2.99 and 2.71, were rated first and second, respectively, for the SHC Sustainable Social Factors. Waste and Pollution (WP), with an average mean of 2.81, was ranked first among the SHC Sustainable Environmental Factors. In contrast, Energy Efficiency (EE) and Materials and Noise Pollution (MN) were jointly rated second with a 2.71 average mean.

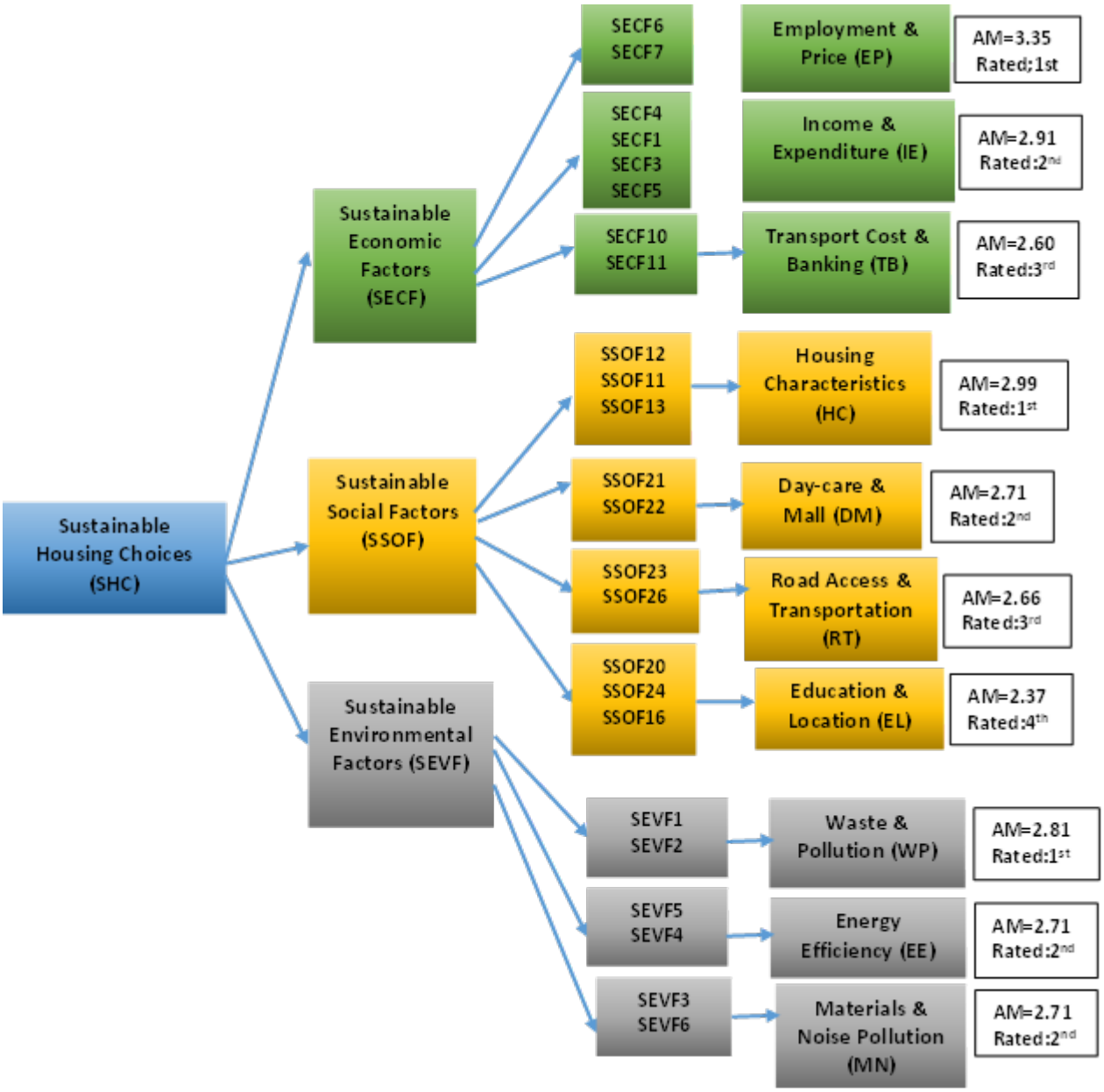

Figure 1 SHC Exploratory Factor Analysis

5. CONCLUSION

The study concluded on the economic, social, and environmental housing choices that both male and female households could make for their rental affordability. The sustainable economic housing choices drivers that household heads can consider for household rental affordability are Employment and Housing Prices and income and expenditure. Employment and housing prices comprise employment opportunities and house prices concerning income. Income and expenditure are the combinations of energy bills regarding income, household income level, rental cost on income, and water bill pertaining to income. Sustainable social housing choices drivers are housing characteristics and access or availability of dare-care and malls. Housing characteristics include housing unit size, household size, and clean and attractive houses, while access to daycare and mall, as well as the availability included location, shopping mall, and daycare for children. Sustainable environmental housing choices drivers are waste and pollution, energy efficiency, as well as materials and noise pollution. The overall conclusion is that there are some similarities in the factors of sustainable housing choices decisions for rental affordability of male and female household heads.

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EMPOWERMENT OF INCREASING ECONOMIC RESILIENCE POST COVID-19 JANJANG WULUNG VILLAGE COMMUNITY THROUGH CREATIVE ECONOMIC VILLAGE PLANNING

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ABSTRACT

Janjang Wulung Village is one of seven villages located at a highland of 593.73 meters above sea level in Puspo District, Pasuruan Regency, East Java. Janjang Wulung Village has natural resource potential from coffee, apples, avocados, and forest products supported by the plantation area, reaching 280.1 and farmers of 1,072 people. The livestock sector is also one of the superior productions in Janjang Wulung Village, with each household having 3-6 dairy cattle with a population of 602 people who work as breeders. However, the condition of COVID-19 limiting social activities resulted in a 20% to 40% decrease in income. So, planning the development of Janjang Wulung Village as a creative economy village is necessary to create an economically resilient village. Four analyses are used, including problem trees, analysis of village and community resilience, and SWOT, followed by the analysis of project alternatives that are resulting projects. The project includes village physical resilience, such as road rehabilitation projects, clean water system development projects, procurement projects, Wi-Fi Corner, food diversification innovation projects, technology development projects, and modules and poster projects using technology to support the development of the creative economy.

Keywords: Economic Risilience; Creative Economy; COVID-19

1. INTRODUCTION

Janjang Wulung Village is divided into five hamlets, namely Kopek Hamlet, Krajan Hamlet, Sembung Hamlet, Lasgung Hamlet, and Delik Hamlet. The creative economy development economy in Janjang Wulung Village can be implemented by assessing the potential and problems. Exploring the potential found, several prospects come from aspects of nature, economy, forest products, agriculture, plantations, and institutions. Prospects at Janjang Wulud are found in food crops and plantation commodities, where the largest food crop production is corn, which amounts to 20,744 tons per year, and for plantations, the largest production is cotton kapok with 352.24 tons per year (BPS, 2020).

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However, problems in Janjang Wulung Village are still found, such as road infrastructure problems using macadam pavement along 19.4 kilometers (km), making it difficult for road users to pass through due to jagged rocks and plains whose elevation is quite steep. The difficulty in getting clean water is also still found even though there is clean water from Umbulan in Dusun Lasgung.

Still, the location in the lowland makes it difficult for the water to flow throughout the village (Survei Sekunder, 2020). In addition, problems related to the COVID-19 Pandemic have made three sub-districts in Pasuruan Regency the Coronavirus red zone, including the Puspo District (Emil, 2020).

Janjang Wulung Village has prevented and handled the COVID-19 virus byass spraying disinfectants on May 1, 2020, as a form of activity for the resilience of the village and village communities (Hidayat, 2020). There are ways to overcome the economic problems currently occurring due to the Pandemic by developing the creative economy through 17 sub-sectors that have been defined and prioritizing local wisdom. All regions in Indonesia, including Janjang Wulung Village, are prioritized as an example of creative economic resilience villages, Puspo District, Pasuruan Regency, East Java are p (Kementrian Pariwisata dan Ekonomi Kreatif, 2020). A creative economy is the development of concepts based on creative assets that have the potential to increase economic growth (Sopanah, Bahri, & Ghozali, 2018). According to the Law of the Republic of Indonesia Article 1 of 2015, the creative economy embodies of added value from an idea or ideas that contain authenticity, emerging from human intellectual creativity based on science, skills, and cultural heritage intellectual property technology. The main elements of the creative industry are creativity, expertise, and talents that have the potential to improve welfare by offering intellectual creations (Rakib et al., 2018).

Human resources determine the empowerment of potential assets, namely, how the community can be skilled at empowering this potential to produce tradeable products (Mayasari & Chandra, 2020). Community empowerment creates a community with much greater control over its environment and the process development of organizational means (Badaruddin, 2020). Assessment in terms of community empowerment is part of the development paradigm that focuses on all the principal aspects of humans in their environment, starting from the intellectual aspect (Human Resources), material and physical aspects, to managerial elements. These aspects can be developed into sociocultural, economic, political, security, and environmental factors (Cristina, 2020). However, there are still problems in implementing empowerment, especially from human resources. The limited means of communication and information cause the public not to know the surrounding environment (Hansson, et al., 2020). So, learning or training is needed regarding knowledge, skills, and attitudes to create independent business opportunities and independence from other parties.

Janjang Wulung Village has both potential and problems. Therefore, a study was conducted that aims to find out how the physical and non-physical conditions of Janjang Wulung Village to examine the resilience of the Janjang Wulung Village community in the COVID-19 Pandemic through the excavation of the leading sector and prepare development directions for Janjang Wulung Village to develop the creative economy during and after the Pandemic. The discourse networking analysis method is expected to systematically identify a discourse relation in various documents to form a complex network. Participatory Rural Appraisal (PRA) and Rapid Rural Appraisal (RRA) are used in this data collection.

2. RESEARCH METHODS

The research method is divided into two. First, a data collection method combines primary and secondary data obtained online. Second, there is a data analysis technique using village and

community resilience analysis as the focus on consideration analysis for planning direction by the resilience condition of Janjang Wulung Village.

2.1. Data Collection

This study uses the online primary and secondary data collection methods which Discourse Networking Analysis analyzes. Discourse Networking Analysis is a technique for visualizing political and sociocultural discourses into a network that allows us to systematically identify a discourse structure in various textual documents such as newspaper articles, print media,r transcripts of debates in parliament (Pratama & Ulfa, 2017). This Discourse Networking Analysis method combines secondary data from PRA (Participatory Rural Appraisal) and primary RRA (Rapid Rural Appraisal) data.

Participatory Rural Appraisal (PRA) is an exercise for communication and transfer of knowledge that gather/collects information by the involvement of Rural/local communities for decision-making and implementation of the development project "for the rural community, by the rural community and with the Rural Community (Arthika, 2020). With the results of PRA, the community will undoubtedly provide potential in themselves. Through this potential, the community can develop the village's potential according to its potential (Harani, 2017). The community-based approach was also chosen because village development in Indonesia is based on community-based development, so existing planning is right on target (Andari, 2019). The PRA was implemented using primary data from the 2018 PRA result and integrated the data received with online interviews due to the Pandemic that led to limited access.

2.2. Data Analysis

The analytical technique used in this research is the analysis of village and community resilience. This analysis of village and community resilience aims to determine the physical and non-physical conditions of Janjang Wulung Village to determine the direction of further development from the consideration of resilience analysis. Resilience is the dynamic condition of an area that includes all dimensions of life that can develop and be integrated into the face of threats, challenges, and obstacles (Mardhani, Runturambi, & Hanita, 2020). Community resilience is a crucial concept of resilience a region or region possesses. Society is a group of people living with all their cultures and personalities (Purwaningsih, 2020). However, it is necessary to use other PRA tools and supporting analysis from this analysis.

The PRA tool to support village and community resilience analysis data uses eight crosschecked PRA data (Comparison of 2018 and 2020 data) consisting of village mapping, village transects, village history flows, Venn diagrams, livelihood studies, input and output flow charts, season calendar, and ranking chart which then identified the problem to find out the leading causes of creative economy development in Janjang Wulung Village by using problem tree analysis. Problem tree analysis is a step in solving a problem by looking for the reason an effect (Asmoko, 2019).

Apart from the problem tree analysis for the PRA Tool, this study also uses other supporting data analysis techniques starting from the ability and land suitability analysis, analysis of settlement facilities and infrastructure, settlement analysis, population analysis, economic income analysis, and policy analysis. After all analysis data has been collected, all PRA and other analytical data are analyzed in the analysis of village and community resilience. In addition, there is also potential and problem analysis, root cause analysis, root purpose analysis, and SWOT analysis, which can be seen in the analytical framework in Figure 1.

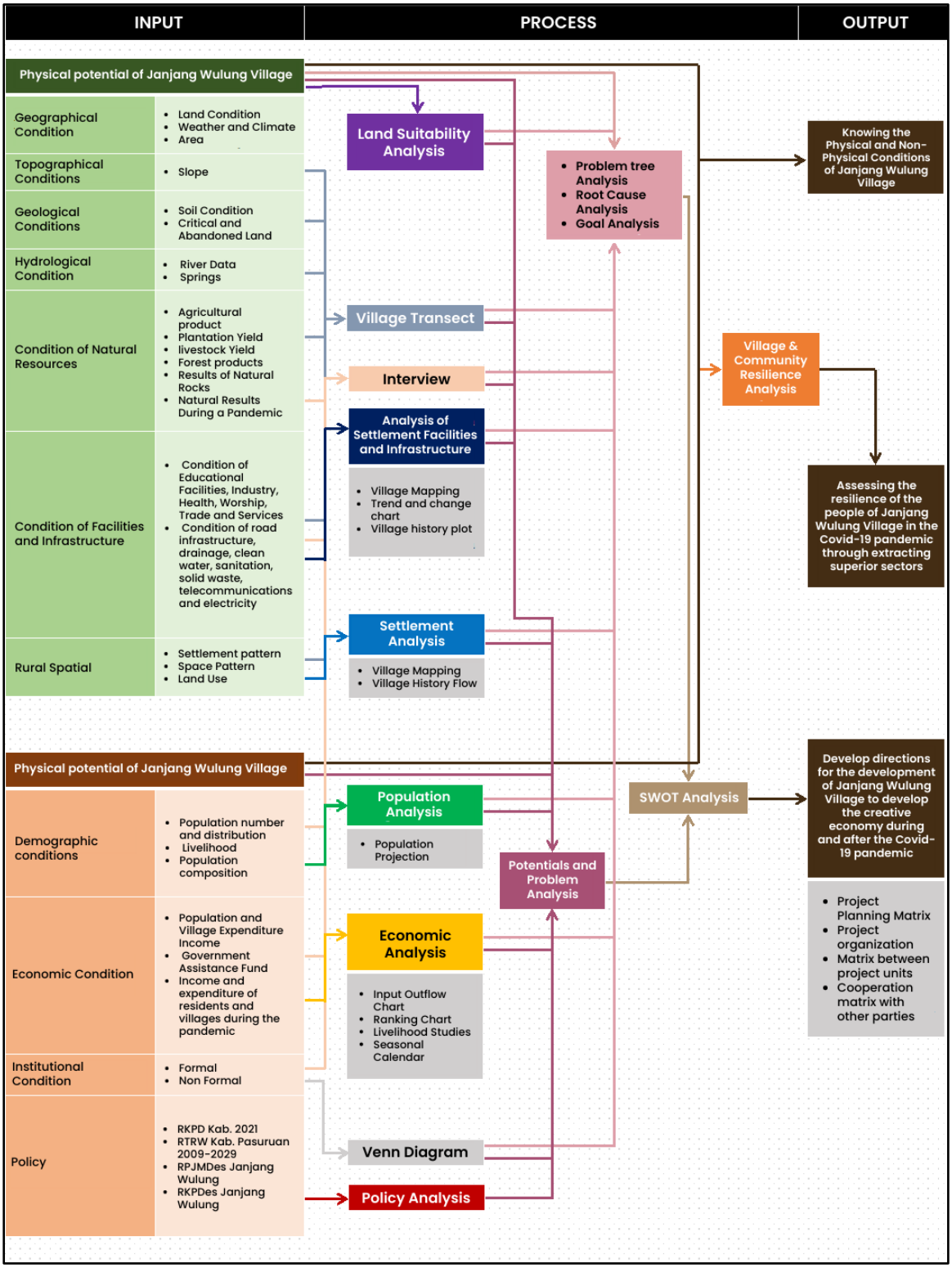

Figure 1 Analysis Framework

3. RESULTS AND DISCUSSION

Janjang Wulung Village is one of seven villages in Puspo District, Pasuruan Regency. The area of Jajang Wulung Village is 7 km2 (14.46% of the total area of Puspo District), with a high population density of 599 people/sqm (see Figure 2). It consists of 5 hamlets: Krajan Hamlet, Lasgung Hamlet, Sembung Hamlet, Kopek Hamlet, and Dusun Delik, 6 Rukun Warga (RW), and 20 Rukun Tetangga (RT). Janjang Wulung Village, located in the Pasuruan Regency area, has a very strategic location because it is a crossroads from Surabaya – Malang, Surabaya – Probolinggo, and from Probolinggo to Malang through the Pasuruan Regency area.

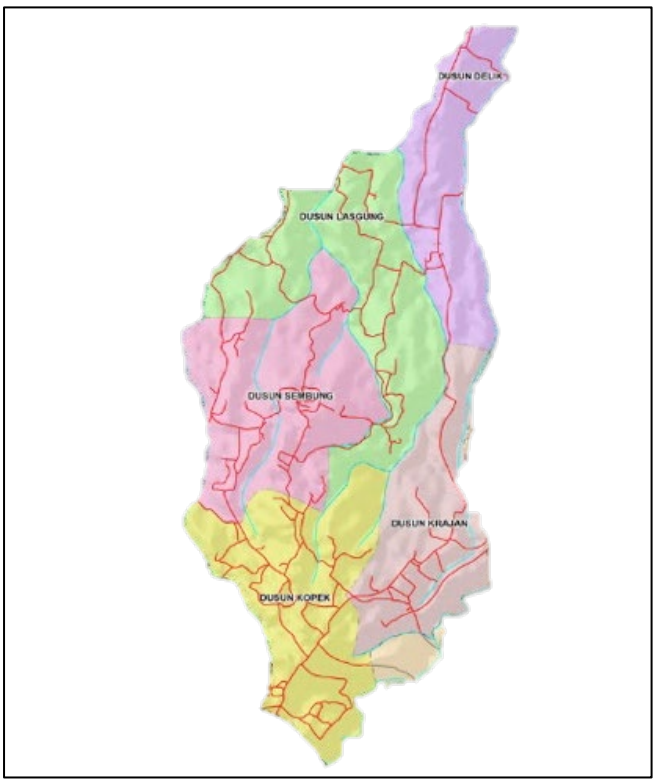

Figure 2 Janjang Wulung Village Administration

Janjang Wulung Village is located at an altitude of 593.73 meters above sea level and in a mountainous area. Therefore, Janjang Wulung Village is included in the highland area. In addition, Janjang Wulung Village has the same slope as Pasuruan Regency and Puspo District, which has a slope between 0-2% (Pasuruan Goverment, 2020). Janjang Wulung Village only has 1 type of soil, namely Andosol soil, so Janjang Wulung Village is included in the medium fertile area with a land area of 261 ha with moderate fertility. The level of erosion in Janjang Wulung Village is relatively light, with an area of only 10 ha, a depth of around 50-99 cm with an area of 218.73 ha, and Janjang Wulung Village has a critical land of 20 ha, which is classified as low.

3.1. Trouble Tree

The analysis results using a problem tree produce details of the cause of an effect which can then be used as a solution to a problem. In addition, this analysis also illustrates the correlation between the problem, the cause of the problem, and the effect of a problem in a hierarchy of interrelated factors (Prayitno, et al., 2022). The following are the results of the problem tree analysis in Janjang Wulung Village (see Figure 3).

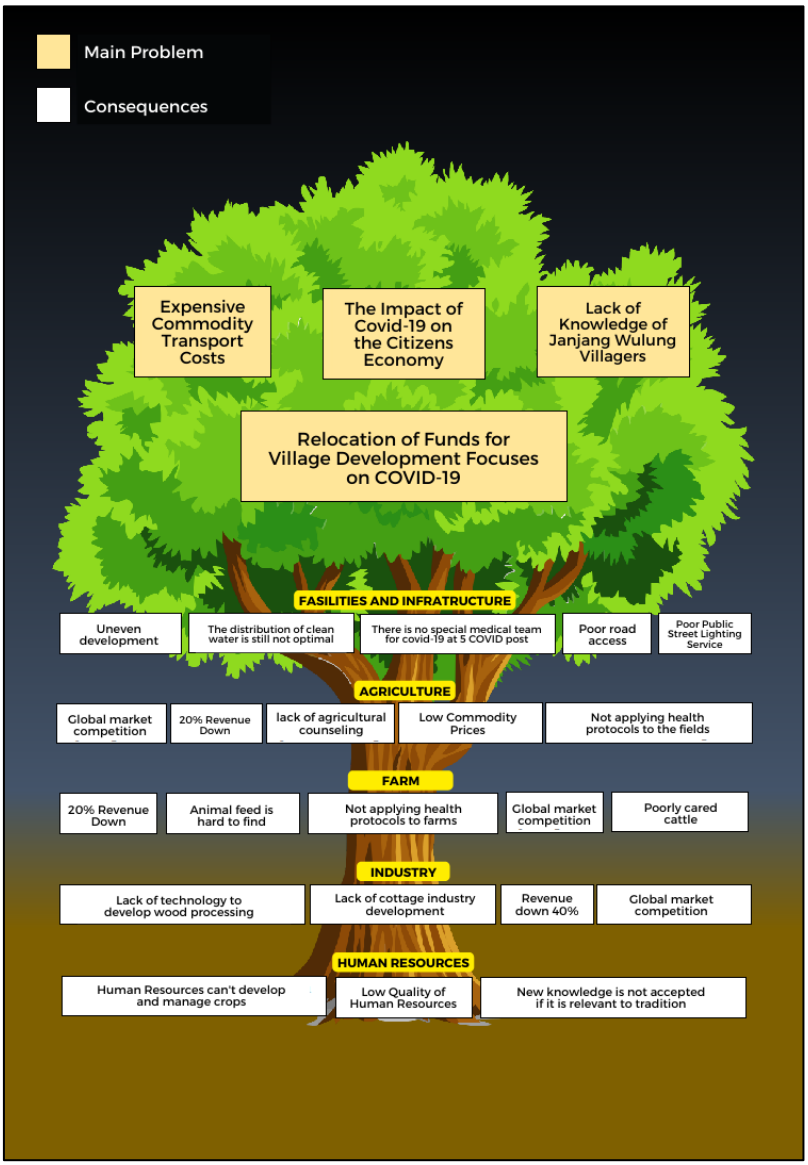

Figure 3 Problem Tree

As seen in the picture, it can be concluded that there is a bad influence or impact from the Pandemic on agriculture, which has resulted in residents having to adjust their needs more than before the Pandemic with farm wages that have not changed. In addition, compared to conditions in 2018, the cattle owned by the residents, which initially numbered 6 heads, were reduced to 3 cows. This is because it is increasingly difficult to get animal feed, so livestock are less well cared. It can also be concluded from all the existing problems that impact citizens' income or the economy slowly.

3.2 Analysis of Village and Community Resilience

Analysis of the village and community resilience is seen from six essential criteria and seven components of assessing existing conditions. The weighting is also based on the six criteria, with one (1) point for each measure if it is appropriate and zero (0) if it is not warranted.

Table 1 Per-indicator Criteria Score

No	Criteria	Information	Score
1.	*Equity*	Guarantee of human rights regardless of background	1
2.	*Quality*	There are services and availability of quality basic materials such as food, clean water, health services, and affordability of transportation	1
3.	*Ecology*	Use of natural resources wisely for now and in the future	1
4.	*Ownership*	Main control of existing resources	1
5.	*Diversity*	Protect and respect cultural diversity	1
6.	*Self-reliance*	Providing and sharing needs in an emergency	1
Total Per-Component Assessment of Village and Community Resilience Analysis			**6**

The essential criteria are Equity, Quality, Ecology, Ownership, Diversity, and Self-Reliance (Surjono et al., 2019). In addition, the assessment components used to assess the condition are divided into local knowledge, community networks and relationships, preparedness, health, resources, governance/leadership, and economic investment. In addition, a Likert scale is also used to assess the resilience of the Janjang Wulung Village and Community.

Table 2 Defensive category determinant assessment

No	Category	Weighting Value
1.	Hold High	26–34
2.	Medium Endurance	13–25
3.	Survive Less	1-12

After the analysis, it was found that Janjang Wulung Village could survive but not optimally, with a total weighting value of 22. This happens because many people in Janjang Wulung Village still have not implemented health protocols properly even though 90% of the residents already know the danger of the spread of the COVID-19 virus, and the assistance provided by the government cannot be felt by all citizens. After all, it is only given to the poor. In addition, it can also be concluded that from residents and villages.

3.3. SWOT Analysis

SWOT is a strategic planning and management tool to build organizational and competitive strategies (Gurel, 2017). The SWOT analysis uses a strategic planning framework that has 2 dimensions internal dimension (weakness and strengths) and also external dimension (opportunities and threats) (Benzaghta et al., 2021). SWOT analysis will produce the best recommendation related to the needs of the client/community, so this analysis will be more targeted and effectively implemented (Groseli, 2015). The identified aspects are divided into internal issues and external issues, which will later be combined to find alternatives to solving threats and weaknesses. The following is a combination or combination of internal and external problems in Janjang Wulung Village.

Table 3 SWOT Analysis Results

Internal / External	S (Strength)	W (Weakness)
	• Janjang village is located in the highlands with good slope stability and fertile andosol soil types for farming. • Good physical condition and scale of service facilities so that they can serve the community • There are COVID-19 Command Posts throughout the village • The drainage network is adequate to drain runoff water and household wastewater • The people of Janjang Wulung Village already have a semi-permanent and non-permanent housing system • The commodities of cassava, bamboo, cloves, durian, and avocado are favorites commodities in Janjang Wulung Village • Abundant cow's milk production • The existence of KUD improves the economy of the villagers • The number of residents scattered throughout the hamlet and the relatively low population growth	• Janjangwulung Village is dominated by high erosion rates with relatively low rainfall • Uneven distribution of facilities • The condition of the road pavement is macadam which makes it challenging to distribute livestock products • Clean water infrastructure is complicated in some hamlets because they still rely on springs from other villages and are obtained in rotation • There are deposits in some drainage channels • Villagers do not accept forms of counseling that are not by tradition • The condition of the road pavement is macadam which makes it challenging to distribute livestock products • Difficult to get feed for livestock • Unequal distribution of population, the lowest population of Dusun Lasgung with the most significant area • The influence given by several institutions is not so great and can be felt by the community
O (Opportunity)	**SO**	**WO**
• The existence of the Pasuruan Regency RTRW policy for 2009-2029 regarding road development has been carried out in Janjang Wulung Village through the construction of road pavements that were previously ground into asphalt and macadam to improve the quality of infrastructure and facilitate transportation of villagers and the addition of the electricity network by establishing a JTM • The existence of the MUSREMBANGDES policy with the construction of communal toilets in Krajan and Kopek hamlets, submission of montong durian seedlings in Sembung and Lasgung hamlets, and construction of public street lighting • There is assistance from the government and Nestle in the care of livestock	• There is a MUSREMBANGDes policy related to developing facilities and infrastructure to improve the quality of existing facilities and infrastructure more optimally than their conditions and services. One is related to sanitation infrastructure with details in the form of building communal toilets in Krajan and Kopek hamlets. • The Pasuruan Regency RTRW 2009-2029 policy regarding road development as the basis for carrying out road repairs to support the existence of KUD to increase the economic improvement of the residents of Janjang Wulung Village. • The Pasuruan Regency RTRW 2009-2029 policy regarding road development as the basis for road repairs to support the distribution of favorite agricultural commodities outside the hamlet and outside the village of Janjang Wulung. • There is assistance from the government and Nestle in livestock care as a basis for increasing animal feed and abundant cow's milk production. • The existence of assistance from the government and Nestle will help increase livestock products.	• There is assistance from the government and Nestle to improve the quality of livestock commodities through counseling due to the poor quality of cattle due to the difficulty of finding animal feed. • The existence of assistance from the government and Nestle in livestock care will improve the quality of commodities and villagers through direct outreach. • The Pasuruan Regency RTRW 2009-2029 road development policy can improve the road pavement's condition, which is still in the form of macadam, to distribute livestock products better. • The Pasuruan Regency RTRW 2009-2029 policy regarding road development facilitates accessibility in the level of service facilities that are still not evenly distributed. • A policy in the RTRW of Pasuruan Regency 2009-2029 regarding improving facilities and infrastructure will help solve the problem of unequal facilities and infrastructure problems, such as clean water.

T (Threats)	ST	WT
• Lack of support from the government • The selling price of agricultural, livestock, and forest products is low due to the difficulty of marketing during the Pandemic	• Using soil fertility in Janjang Wulung Village for good agricultural management will reduce the threat of the lack of government support for the farming sector. • Good management of only commodities such as cassava, bamboo, cloves, durian, and avocado will minimize the threat from the difficulty of commodity marketing during this Pandemic. • Improving the quality of service and the physical condition of the facilities will eliminate the threat of the lack of government support for the shape of the existing facilities in Janjang Wulung Village. • The management of the COVID-19 Command Post and Polindes health facilities will minimize the threat from the government that does not support the condition of health facilities. • The existence of KUD, which helps the production of cow's milk which is relatively abundant, can improve the economy of farmers despite the threat of difficult marketing in this Pandemic.	• The uneven distribution of facilities can be minimized by building and rehabilitating facilities to avoid threats from the lack of government support for the condition of facilities in Janjang Wulung Village. • Improving the quality of accessibility can reduce the weakness of residents who have difficulty distributing milk from cows whose rate has decreased due to wobbling on the roads to avoid threats from the lack of government support for the existing road network in Janjang Wulung Village. • The development of the quality of livestock activities in animal feed technology processing can minimize farmers' difficulty obtaining animal feed to avoid the lack of government support for the livestock sector. • The development of the Clean Water Network can minimize the difficulty of clean water infrastructure due to the condition of the topography of Janjang Wulung Village which is getting higher and higher so that several hamlets at an altitude still have to get clean water in rotation. • Training on relevant technology can overcome the knowledge of the residents of Janjang Wulung Village who cannot accept new insights, especially in the use of natural resources if they are not relevant to existing traditions to avoid marketing difficulties for superior commodities in this Pandemic. • Improving institutional performance can increase institutional influence on the people of Janjang Wulung Village which currently does not have much effect on the utilization of human resources, this can also be a strategy to avoid threats from the lack of government support for institutional influences.

3.4. Development Concept

Janjang Wulung Village has a low community welfare condition because the fulfillment of the economic and social needs of the community is still not optimal. In meeting financial requirements, most people with a livelihood in the agricultural and livestock sectors still need help marketing each sector's commodity products. This is because the road infrastructure is not in good condition. There is a steep road terrain, damage to several sections, and a lack of completeness of the road, so residents have difficulty doing marketing. The condition of road infrastructure like this causes difficulties in the process of using the mode of transportation so that when it reaches the market, the selling price of the results will be low.

The people of Janjang Wulung Village are still not optimal in meeting social needs. Based on the results of the analysis carried out at the facts and analysis stage, related to meeting the demand for clean water, the community is still experiencing difficulties because the source of clean water

has not been able to cover the entire hamlet (see Figure 4). However, using pure water sources from other villages, the fulfillment of clean water is still constrained by quality and quantity. In the dry season, the amount of water decreases due to drought; in the rainy season, the water quality becomes cloudy. The people of Janjang Wulung Village already have access to their telecommunications needs. However, there are still obstacles related to providers who can only cover some hamlets and unstable network conditions. The condition of human resources in Janjang Wulung Village is still not good due to the role of institutions that have not been maximized and the absence of counseling for community groups in Janjang Wulung Village. The lack of this role has resulted in the people of Janjang Wulung Village being unable to optimize their needs or resources. The community does not yet have sufficient knowledge to manage production and market commodity products.

The condition of the COVID-19 Pandemic is also one thing that affects the shape of Janjang Wulung Village. With this condition, the village economy can contract and lead to a recession which impacts rural communities due to the declining level of purchasing power. This can limit the communication and social level of the village community and reduce the productivity of various sectors in Janjang Wulung Village.

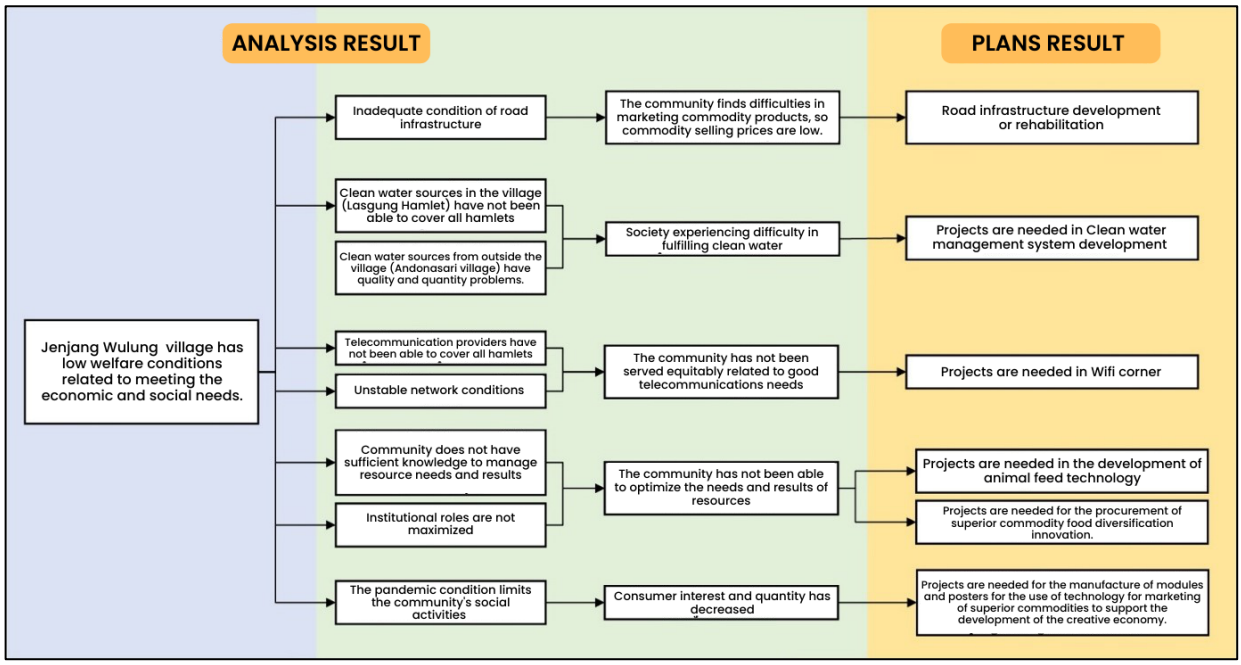

Figure 4 Janjang Wulung Village Development Concept Flowchart

Before realizing the directives for the plan to develop Janjang Wulung Village, a Project Alternative Analysis is needed, which determines the priority of programs or projects in Janjang Wulung Village based on the results of the Focus Group Discussion. The steps taken in determining the priority of the program or project in question are as follows.

3.5. Determination of Criteria

Criteria are determined based on the interest and priorities of the parties involved. Thus, 13 criteria were set according to the Project Alternative Analysis (AAP) that had been determined. The thirteen criteria are maximum beneficiaries, increased income, increased use of human resources, availability of natural resources, sustainability, duplication, replicability, inter-village project linkages, tool-to-purpose relationship, ecological considerations, contribution to

district/municipality strategic programs, the priority order of development principles with the region, and relation to the previous year's program.

1. Determination of Weighting Value
   This value-weighting stage is carried out by assigning a value to each existing project alternative using predetermined criteria. The following is the weighted value of the Likert Scale to assess AAP.
   1 = Very Low
   2 = Low
   3 = Enough
   4 = Height
   5 = Very High
2. Determination of Project Alternatives (AAP)

Table 4 Project Rating Matrix

No. Project	Project	Score	Rank
1	Road Construction and Rehabilitation Project	427.5	I
5	Clean Water System Management System Development Project	422.4	II
8	Wifi Corner Procurement Project	412.5	III
4	Animal Feed Technology Development Project	400	IV
7	Module and Poster Development Project Using Technology for Leading Commodity Marketing to Support Creative Economy Development	392.5	V
6	Procurement of Leading Commodity Food Diversification Innovation	385	VI
2	Health Facilities Rehabilitation and Performance Improvement Project	360	VII
3	Education Facility Improvement and Performance Improvement Project	337.5	VIII
9	Institutional Performance Improvement Project	260	IX

Based on the project rating and identification of the physical and non-physical potential of Janjang Wulung Village, plans or directions for developing the village and community are determined. The following is a table of orders for the plan to develop Janjang Wulung Village.

Table 5 Directions for the Janjang Wulung Village Development Concept Plan

Plan Form	Plan Direction	Alternative Plan	Plan Purpose
Spatial Structure Plan	Accessibility Quality Improvement	Road Construction and Rehabilitation	Village Physical Fulfillment
	Clean Water Network Development	**Development of Clean Water System Management:** Addition of Piping Network	Village Physical Fulfillment
Space Pattern Plan	Facility Construction and Rehabilitation	**Repair and Improvement of Health Facilities Services:** Construction of New Classroom	Village Social and Physical Fulfillment
		Procurement of wifi Corner	Village Social, Economic, and Physical Fulfillment
		Development of Clean Water System Management: Addition of Reservoir and Clean Water Pump	Village Physical Fulfillment
		Repair and Improvement of Health Facilities Services: Polindes Building Rehabilitation	Village Social and Physical Fulfillment

Plan Form	Plan Direction	Alternative Plan	Plan Purpose
HR and Natural Resources Fulfillment Plan	Quality Development of Livestock Activities	Animal Feed Technology Development	Economic Fulfillment
	Improved Quality of Leading Commodities	Procurement of Leading Commodity Food Diversification Innovation	Economic Fulfillment
	Training on Using Technology for Leading Commodity Marketing	Making Modules and Posters on the Use of Technology for Marketing Leading Commodities to Support Creative Economy Development	Social and Economic Fulfillment
	Improving the Quality of Health Services	**Repair and Improvement of Health Facilities Services:** Improving of Polindes Services	Social Fulfillment
	Improving the Quality of Education Services	**Improvement and Improvement of Educational Facilities Services:** Improving Education Facilities	
	KUD Performance Improvement	Institutional Performance Improvement	
	LPM Performance Improvement		

The spatial structure contains plans for service centers, service sub-centers, and linkage systems. After being identified, it gave rise to Krajan Hamlet as a service center, Kopek Hamlet as a service sub-center, with directions for improving the quality of accessibility and clean water networks See Figure 5 and Figure 6).

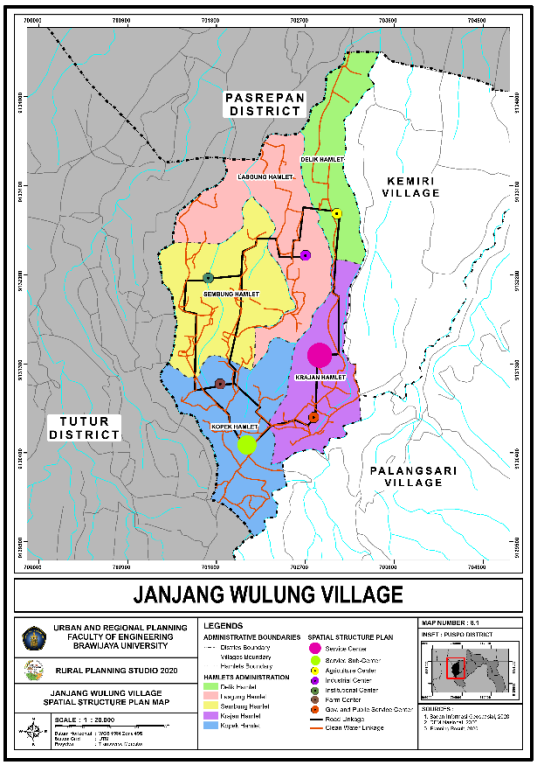

Figure 5 Janjang Wulung Spatial Structure Plan

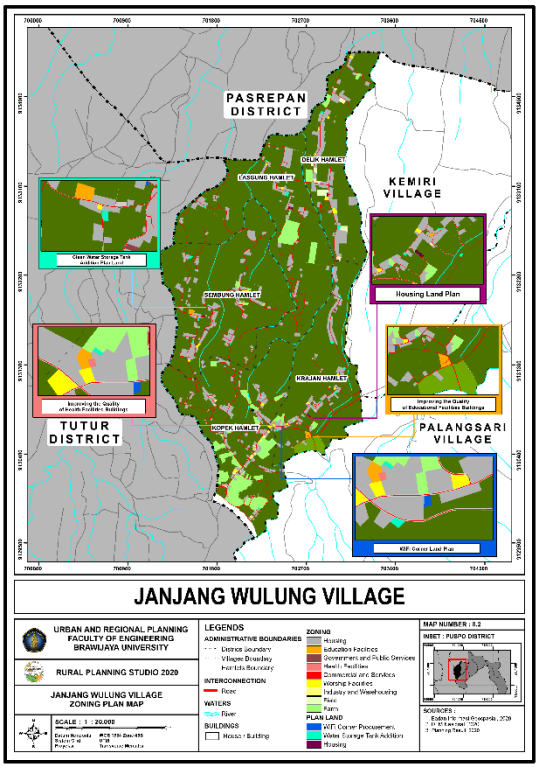

Figure 6 Janjang Wulung Spatial Pattern Plan

In addition, the spatial pattern plan itself discusses the plan to add land, especially for clean water facilities, educational facilities, health facilities, wifi corner facilities, and residential land.

Finally, the plan for fulfilling human resources and natural resources itself contains the direction of programs for the development of natural resources through the improvement and utilization of

human resources, which includes a non-physical plan for Janjang Wulung Village, which can be seen in Table 5.

So, from the plan, it is redefined to the needs based on the village and its community. It is divided into the physical resilience of the village and the non-physical resilience of the village community. The following is the division of projects based on the fulfillment of resilience.

Village Resilience: The fulfillment of village resilience is physical. This is explained by the conditions of Janjang Wulung Village, such as the road network, clean water, and telecommunications. So, the projects below were made to meet the village's resilience from its physical condition.

Road Rehabilitation Project: This project targets the rehabilitation of macadam roads and damaged roads into asphalt or paving roads to improve the hampered distribution process.

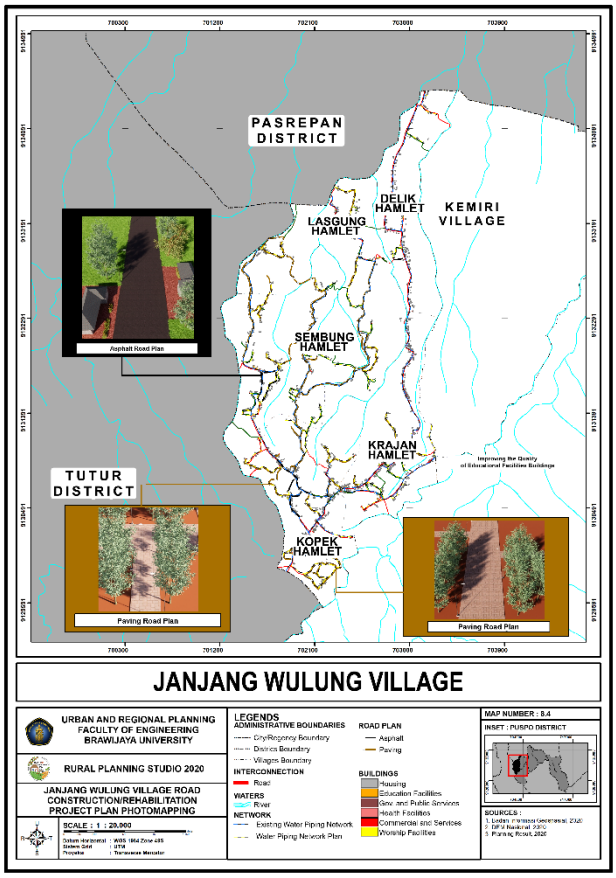

Figure 7 Photo Mapping of the Janjang Wulung Village Road Rehabilitation Project Plan

Clean Water System: This project aims to add clean water reservoirs, pipelines, and pumping systems to facilitate the distribution of clean water in Janjang Wulung Village (see Figure 8).

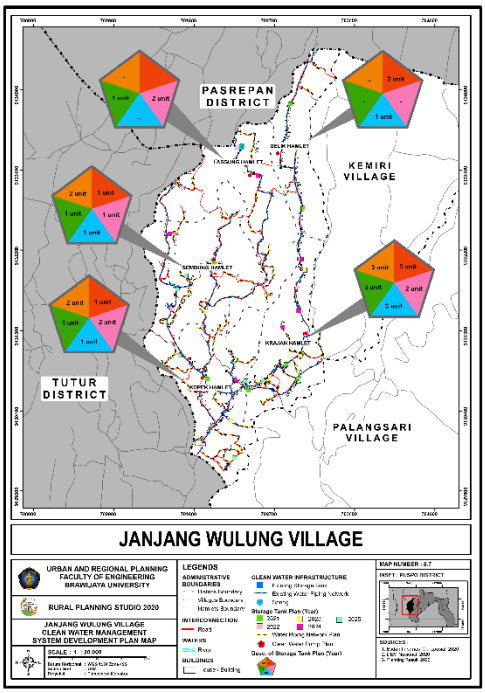

Figure 8 Janjang Wulung Clean Water System Plan

Wifi Corner Procurement Project: This project aims to fulfill network coverage for all hamlets so that the community can take advantage of the network related to online commodity marketing (see Figure 9).

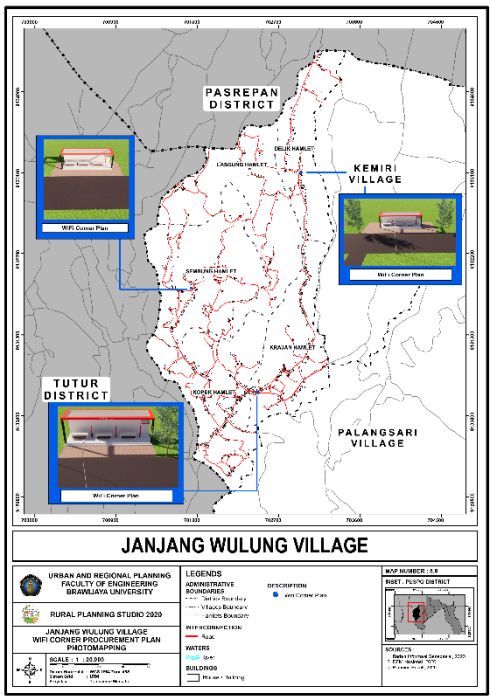

Figure 9 Photo Mapping the Plan to Procure WI-FI Corner in Janjang Wulung Village

Community Resilience: The plan's direction on community resilience discusses the non-physical plan of Janjang Wulung Village. This plan aims to meet the community's non-physical needs to

support the creative economy's development. There are three projects of community resilience as follows.

Food Diversification Innovation Project: This project aims to fulfil the food security of the people of Janjang Wulung Village. In addition, this project is not only for food security but also one of the developments of the creative economy, namely the culinary sub-sector. Hopefully, with this project, the community will be able to utilize and adequately cultivate the potential of existing natural resources and gain profits if they are marketed.

Project for Making Modules and Posters on Using Technology to Support Creative Economy Development: This project was implemented to support projects directed at Janjang Wulung Village. This project contains methods and information related to the use of technology, especially online marketing of commodities. So, this project hoped to support the insight of the people of Janjang Wulung Village to improve their economy.

Animal Feed Technology Development Project: This project is aimed at cattle farmers. With this project, it is hoped that farmers can collaborate to utilize agricultural waste in animal feed. So, it is expected that farmers will have no difficulty finding animal feed again.

4. CONCLUSION

Based on the results of the analysis that has been carried out, a project is needed to develop the village's potential during and after the COVID-19 Pandemic to achieve the welfare of rural communities in terms of economic and social fulfillment. Projects that can be carried out are the construction or rehabilitation of road infrastructure, and this is related to the majority of the population's livelihoods being farmers and breeders so that it can facilitate the marketing of commodity products, little decrease in selling prices during the process of going to the market and can support the social-economic fulfillment of rural communities. The second project is the development of a clean water management system. This project aims to meet the need for clean water so that the village community can obtain a good supply of clean water. The third project is the development of animal feed technology. With the inpri project, the village community will understand or know about alternative animal feed procurement, which is related to the livestock products produced. With good animal feed procurement, it is hoped that products with reasonable selling prices will be obtained to help the local economy. The next project is the procurement of superior commodity food diversification innovation. With this project, innovation will be carried out on commodity products to increase buying interest and selling prices and help improve the people's economy. The next project is the procurement of Wi-Fi Corner, which aims to meet the telecommunications needs of rural communities so that they can cover the entire hamlet with good quality. This project can also be used to develop village potential during and after the COVID-19 Pandemic. The next project is training in the use of technology for the marketing of superior commodities, and this project aims to increase the community's ability and knowledge of technology so that they can use it in marketing superior commodities so that they can survive during and after the COVID-19 Pandemic. Marketing superior commodities from these various sectors can assist the community in meeting economic needs. With these projects, it is hoped that the people of Janjang Wulung Village can optimize the potential of villages from various sectors to meet social needs.

With the preparation of these recommendations, it is expected to be able to plan a project that can overcome problems from the agricultural, livestock, institutional, economic, facilities and infrastructure sectors by developing the potential of Janjang Wulung Village during and after the

COVID -19 pandemic to be able to achieve good village community welfare in meeting economic and social needs.

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AN ASSESSMENT OF URBAN CHANGE AND ITS DRIVERS IN SULEJA LOCAL GOVERNMENT AREA OF NIGER STATE, NIGERIA

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ABSTRACT

The knowledge of urban change is critical to the management and planning of urban areas. Robust geospatial technologies have increasingly enhanced our understanding of urban change. This paper employs remote sensing and GIS data from the earth explorer data archive to assess the character and pattern of urban change in Suleja Local Government Area (Niger State in Nigeria) and its drives from 1987 to 2019. The nature and character of urban change are examined from the lens of the urban intensity index and the urban land use/cover change. Data from the geospatial techniques were corroborated with secondary data from the Niger State Regional Plan, Suleja Master Plan, and the Abuja Master Plan. The underlying drivers of urban change within this period were also examined. This study reveals that Suleja Local Government Area experienced unprecedented growth in its urban area from 1987 to 2019. Using Qiuying's mathematical model for the urban change intensity index, the study revealed that the urban change intensity index of Suleja developed from low urban intensity (0.16) to highly rapid urban intensity (0.73). The highly rapid urban intensity index witnessed in Suleja was dominated by an edge expansion urban form of change associated with urban sprawl. This study further reveals that the present physical development activities in Suleja are not sustainable. This study, therefore, recommends articulated urban planning for Suleja LGA; also, the outdated Niger State Regional Development Plan and Suleja Master Plan should be reviewed by the Niger State Government.

Keywords: Population; Suleja; Urban Change; Urban Density; Urban Sprawl

1. INTRODUCTION

Cities of the world are experiencing rapid urbanization due to an increase in urban population growth (He, 2018; UN, 2018). It is envisaged that by the year 2050, 72% (6.3 billion) of the world's population will be living in an urban area (UN, 2018), which means that more urban land will be required for physical development in the future. The rapid urbanization experienced in cities would also define the future urban change forms, influencing the urban infrastructure layout, agglomeration of socio-economic activities, and future urban land uses (He et al., 2018).

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Edge expansion describes the new development along an existing development; infilling defines the latest development within an already established urban area while outlying (Leapfrog) development occurs away from the current built-up areas separated by open spaces (Forman, 1995). Urban changes due to urbanization can be limited to the changes in urban form alone and the alteration of the urban landscape (Fabeku et al., 2018; Senanayake et al., 2013; Yu & Zhou, 2017). Landscape alterations are frequently evident in the land use land cover changes in urban areas influenced by increasing anthropogenic activities (Buba et al., 2016; Weng, 2007). The urban changes in urban forms and landscape alteration manifest in various Nigerian cities, accompanied by urban planning problems such as congestion, deterioration of infrastructures, and uncoordinated urban planning (Olujimi, 2009). Suleja Local Government Area of Niger State is faced with similar planning problems.

The Nigerian Federal Government urban policy of 1976 declaring Abuja the new Federal Capital City (FCC) brought Suleja Local Government Area to the limelight due to its proximity to Abuja. Since the relocation of the FCC from Lagos to Abuja in 1991, Suleja LGA has been experiencing unprecedented urbanization. Due to the resettlement scheme of the Federal Capital Development Authority between 1979 and 2007, Suleja witnessed a large influx of people from the new capital territory (Maxlock, 1979; Maxlock, 1987; The Center on Housing Rights and Evictions Social and Economic Right Action Center, 2008). Also, individuals seeking economic opportunities from other parts of the country see Suleja as a dormitory town owing to the low accommodation cost (Auta, 2021; Buba et al., 2016). The rapid urbanization witnessed in Suleja has led to slum emergence, overcrowding, and near infrastructure collapse.

Previous Studies in Suleja LGA by Buba et al., 2016, and Ejaro & Abdullahi, 2013 covered the spatial extent of Suleja from 1980 – 2015 and 1987 – 2012, respectively. These studies focused on the rate of change in Land use within a target period of 2013 and 2015 using Landsat imageries of three epochs. The Study by Buba et al. (2016) further simulated the population and the land use of Suleja LGA to 2035 to monitor future changes. These two studies had inadequate Spatiotemporal coverage for Suleja land use and less emphasized the processes of urban land change and the resultant patterns of change. The methodological gaps identified in the previous studies (Buba et al., 2016; Ejaro & Abdullahi, 2013) were filled in this study, as against the three multi-temporal satellite imageries used by the previous studies. Four different multi-temporal satellite imageries (1987, 1999, 2007, and 2019) were used for this study to have better Spatiotemporal coverage of land uses and to describe the processes of urban change and the pattern of urban transformations that have taken place during the study period (1987-2019).

This study also harnessed the robustness of remote sensing and geographical information system tools. Over the years, remote sensing and GIS tools have proven effective in analyzing and detecting changes in urban areas at local, regional, and global scales (Deng et al., 2009; Lambin et al., 2003). The robustness of remote sensing and GIS can be seen in their ability to offer historical multispectral data sets that cover a study area with precise spatial position and high temporal frequency (XIAO et al., 2006 in Yin, 2010). Accurate temporal mapping using remote sensing and GIS is essential for better urban management and the development of sustainable cities by urban planners (Li et al., 2015). Against this background, this study assessed the urban change in Suleja from 1987 to 2019. To carry out this assessment, the trend of urban change and its change pattern was analyzed from 1987 to 2019. The drivers of urban transformation in Suleja were also examined to achieve the aim of the study.

2. LITERATURE STUDY

2.1. Concept of Urban Change

Urban change is referred to the process responsible for the changing forms of urban centers (Fabiyi, 2006). The term urban change has been conceptualized in different ways by various authors. For instance, urban change is explained in terms of the increasing urban population density due to migration (rural-urban), thereby changing a region's urban center or metropolitan area (Rawding, 2012). Similarly, to the definition of urban change by the authors mentioned above Ehlers & Floor (1993); Phadke (2014) defined urban change as an increase in population density of an urban area, change in spatial extent, and reorganization of urban space. Ehlers & Floor (1993) went further to integrate the economic changes that have taken place in a region in conceptualizing urban change. On the other hand, urban change was conceptualized in terms of changing urban policies and evolving development plans in a metropolitan area (Nas & Theuns, 2005; Nkambwee, 1982; Mukwaya et al., 2010). The urban and development plans could include urban renewal, land, and housing reforms.

Though the concept of urban change may vary among authors (He et al., 2018; Liu et al., 2010; Wilson et al., 2003; Yu & Zhou, 2017), the pattern/forms of urban change manifest themselves in three patterns which are infilling, edge expansion and outlying expansion. The infilling is defined as a new development occurring within previously developed areas. An edge expansion occurs when new developments arise close to the edge of the fringe of existing development; such a pattern or form of growth is called outlying growth. According to He et al. (2018), a more dispersed urban form is noticed in edge and outlying expansions, while infilling leads to a more compact urban form.

However, from the deductions made from previous studies, the term urban change was conceptualized as an increase in population growth and the spatial shift that has occurred in an urban area over the years, with changes taking the form of infilling edge and outlying.

2.2. Study Area and Scope

Suleja is a traditional Emirate located in Southeast Niger State with attractive inselbergs (Maxlock, 1987). Suleja is situated between latitude 9º 08'00.16" N to 9º16'00.17" N and Longitude 7º08'00.13" E to 7º12'00.13" E (See Figure 1). Suleja has ten administrative wards, namely; Bagama' A', Bagama' B', Wambai, Hashimi' A', Hashimi' B', Iku South I, Iku South II, Magajiya, Maje, and Kurmin Sarki. The proclamation of Abuja in 1976 as the Federal Capital Territory gave Suleja Local Government Area more prominence, with the urban area becoming a satellite town to the new capital city. A regional plan and a master plan were prepared to guide its development in 1979 and 1987, respectively, by the Niger State government. Suleja is about 20 kilometers (km) north of Abuja, the Federal Capital City of Nigeria. This study was limited to the ten administrative wards aforementioned, while the pattern/forms of change considered for this study were edge, infill, and outlying.

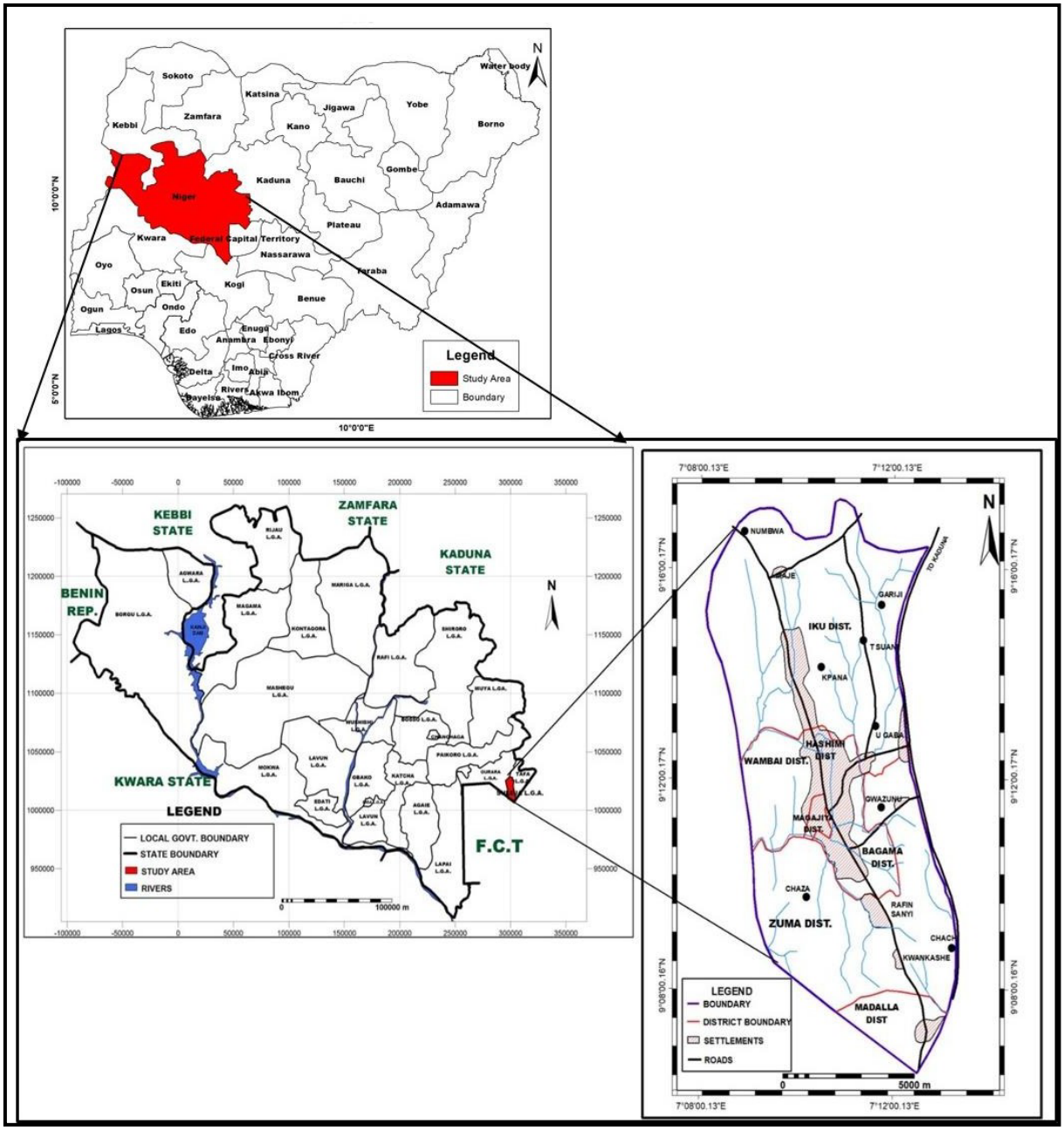

Figure 1 Suleja Local Government Area – Niger State, Nigeria
(Source: Department of Urban and Regional Planning, FutMinna, 2021)

2.3. Data Source, Post-Processing, and Sample Size

A longitudinal design was adopted for this study since it involves a time series analysis. Based on availability, the Landsat data sets were used for this study. Horizontal land uses land cover data were extracted from three sets of Landsat imageries covering a 32-years period. The Landsat data sets used were the thematic mapper (1987), the Enhance thematic mapper (1999), the Enhance thematic mapper plus (2007), and the Operational land imager (2019). These imageries were downloaded from the US Geological Survey (earthexplorer.usgs.gov). The gap mark of the imagery of 2007 was corrected using the "fill no data" tool on QGIS 3.14.16. Bands 3, 2, and 1 were used to form the false color composite for the imagery of 1987. The false color composite for the imageries of the years 1999 and 2007 was developed using bands 4, 3, and 2. Bands 5, 3, and 2 were used to form the false color composite of the imagery of the year 2019 (Figure 2).

The areas of interest were subsets, and five training sets were created on each of the subset imagery. The training sets created are forest land, built-up areas, farmlands, waterbodies, and bare surfaces (Table 1). These training sets were further classified using the maximum likelihood classifier on ArcGIS 10.2 software. The methodological flow chart of this study is represented in Figure 3.

The Open Data Kit (ODK) was used to collect data on the neighborhood quality of Suleja LGA residents. The household population of 53,902 served as the sample frame for the study area. The sample size of each of the ten administrative wards of Suleja was calculated using the Miller & Brewer (2003) mathematical model with a confidence level of 95% and a confidence interval of 5%. A total of 149 sample size was inferred for the entire study area. The proportional sampled technique was used to administer the 149 questionnaires to the household heads randomly selected from each administrative ward.

Table 1 Description of Training Sets of Suleja

Training Sets	Description
Built-up Areas	Land used for residential (Settlements), commercial, industries, institutions, transportation routes, and other impervious surfaces.
Water Body	Land covered with water.

(Source: Adopted from the administrative map of Suleja)

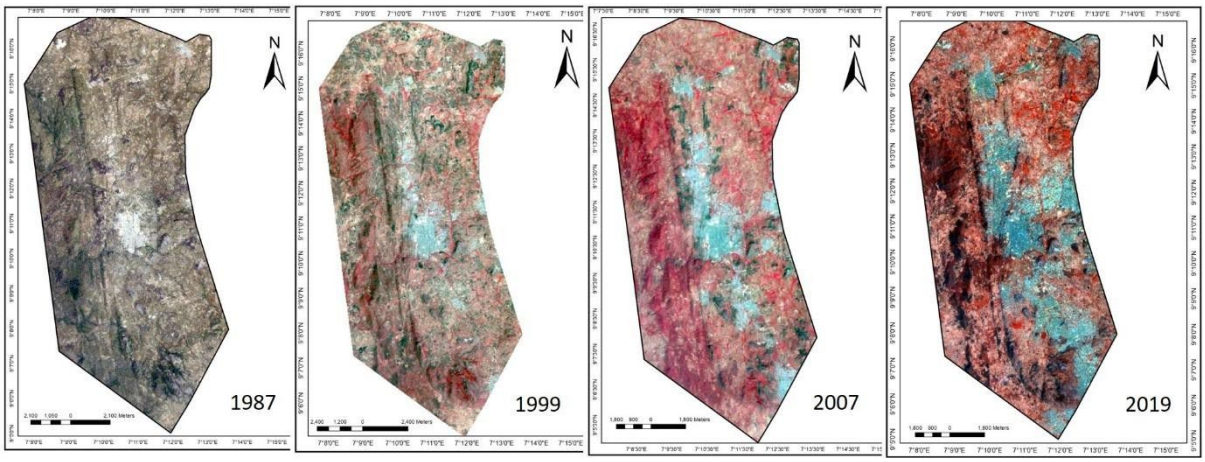

Figure 2 Subset False Color Composite of Suleja
(Source: Author's Analysis, 2021)

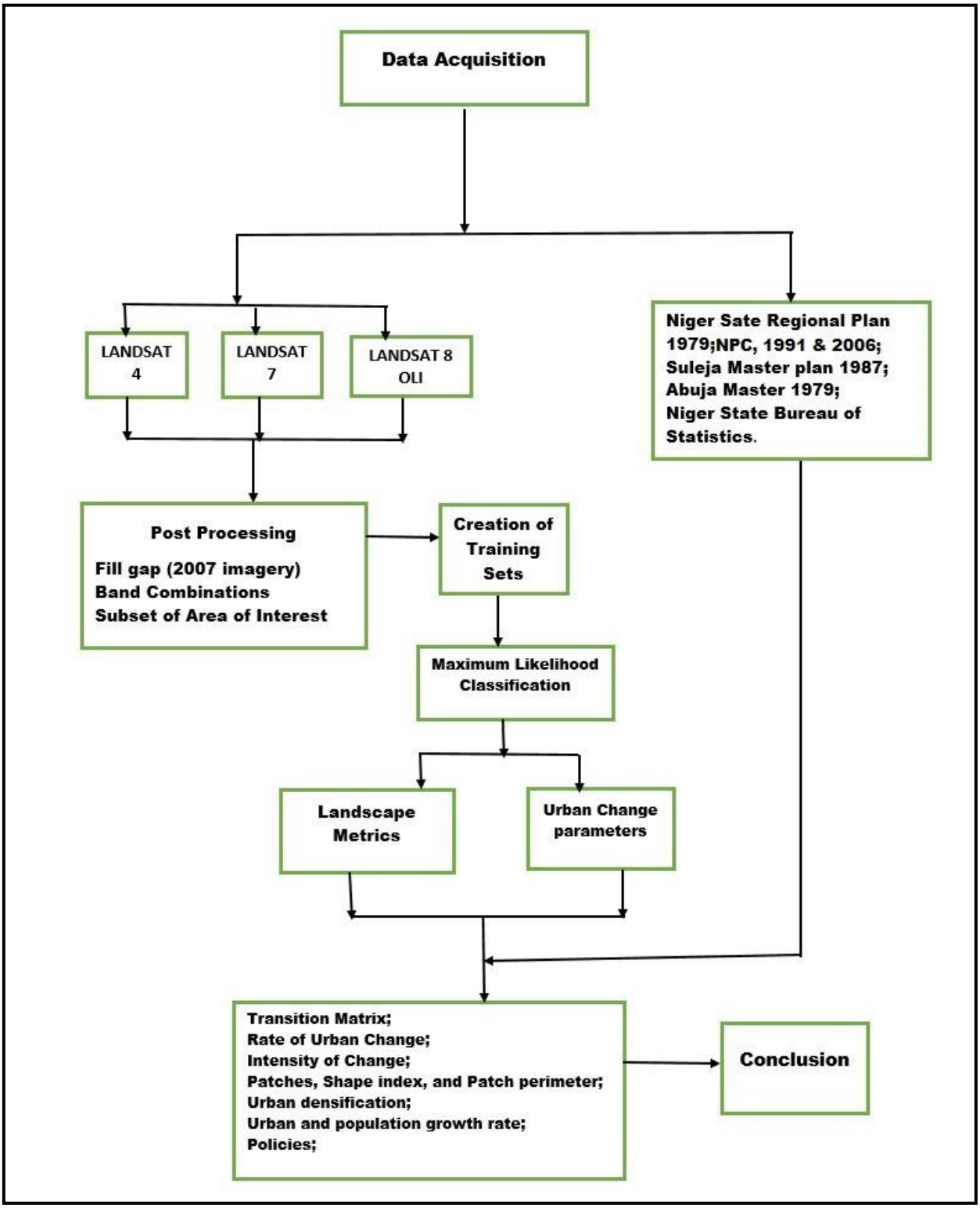

Figure 3 Flow Chart of Methodology
(Source: Author's Construct, 2021)

3. METHODS

3.1. Urban Change Process

3.1.1 Urban Land Transition Matrix

This matrix was used to analyze the transition of urban lands into other land use/ cover features in Suleja by cross-tabulating land use land cover statistics for different years. The transition

matrix shows the growth and losses of each land use land cover throughout the study periods. The urban land transition matrix is often used to manage land use/ land cover for sustainable urban planning (Al-sharif et al., 2017; Shifaw et al., 2018). The transition matrix for this study was generated using the land change modeler on Terrset 17.0 software.

3.1.2. Annual Average Rate of Urban Change

A mathematical model adopted from Shifaw et al. (2018) was used to calculate the annual average rate of urban change in Suleja, and this model is expressed as follows:

$$AARUC = \left(\frac{A_2 - A_1}{A_1}\right) \times \frac{1}{N} \times 100$$

Where; A_2 is the urban areas at the end of a target year. $A_1$is the beginning of a period while N is the number of years between $A_2 - A_1$

3.1.3. Annual Average Urban Change Intensity Index

The Qiuying et al. (2015) equation was used to determine the annual average urban change intensity of Suleja within the 32 years study period. The yearly average urban change intensity comprises five indices which are; very low [< 0.1], low [0.1 – 0.2], moderate [0.2 – 0.4], rapid [0.4 – 0.7] and highly rapid [≥ 0.7]. The Qiuying et al. (2015) equation is expressed as:

$$UCII = \left(\frac{A_2 - A_1}{A_1}\right) \times \frac{100}{\mathrm{TA}}$$

where,

A_2 is the urban areas at the end of a period

A_1 is the urban areas at the beginning of a period

N is the number of years between the end of a period (A_2) and the beginning of a period (A_1), TA is the total land area.

3.1.4. Urban Change Type

Three forms of urban change (Edge, Outlying, and Infilling) were considered in Suleja LGA. Edge changes occur on the fringe of an existing urban area; Outlying urban changes are the form of urban change far from an existing urban area. At the same time, the infilling urban changes were noticed within a current urban area. These changes were determined in Suleja LGA by an overlay analysis of the existing urban area (previous years) and the newly formed urban areas within the study period.

3.2. Secondary Source of Data

Historical information on the socio-economic data of Suleja L.G.A. was sourced from the Niger State Regional Plan of 1979, the Suleja Masterplan of 1987, the Abuja Masterplan of 1979, and the Niger State Bureau of Statistics. Population data from the 1991 population census and 2006 population were obtained from the Nation Population Commission (NPC, 1991; NPC, 2006). The population Figure for 1991 was projected to 1999 using a growth rate of 2.5. The population Figure of 2006 was projected for 2007 and 2019, with a growth rate of 2.5. The population Figures were cast using the Malthusian exponential population projection model. The Malthusian exponential population projection equation is a standard model used to describe the population growth of a unit or region. This model defines population growth as an increase in the size of a population over a specific period using two factors of time and number of people. Unlike other

projection models, the Malthusian exponential model is useful for developing intuitive ideas and estimations about populations of a given region.

The Malthusian exponential population projection model is given as:

$$P(t) = P_0 e^{rt}$$

Where: P_t and P_0 are the estimated population and base year population, respectively; r represents the annual growth rate, while t stand for the difference in the time lag between the present population and the target year.

4. RESULTS

4.1. Trend of Change in Suleja between 1987 and 2019

4.1.1. Land Use/Land Cover of Suleja between 1987 and 2019

The land use of the land cover of 1987 portrays Suleja as an Agrarian settlement with forest lands and farmlands covering ample of the total land area (Table 2). Low built-up areas (2.98%) were also recorded in this epoch; according to the Master plan of 1987, the residents of Suleja at that time were mainly indigenes whose primary occupation was farming (Maxlock, 1987). The relocation of the Federal Capital Territory from Lagos to Abuja in 1991 impacted the land use land cover of Suleja in 1999. During this period (1999), the Built-up area increased to 11.75 square kilometers (km^2) as against the 7.14 km^2 recorded in 1987. The magnitude of change in built-up areas between 1987 and 1999 was 4.61 km^2. The increase in built-up areas in 1999 was also consequential to the rise in farmlands and decrease in forest lands. It is because competing land use, such as human settlements and demand for charcoal and fuelwood leads to deforestation (Ejaro & Abdullahi, 2013). As a result of weathering and other anthropogenic activities such as mining, the waterbodies in Suleja expanded in land areas in 1999 to 32.86 km^2 as against 13.69 km^2 recorded in 1987. Also, due to increased anthropogenic activities in 1999, bare surfaces stretched in land areas with a magnitude of change of 1.64 km^2.

Table 2 Trend of Urban Change in Suleja between 1987 and 2019

Year	1987		1999		2007		2019	
Class	Land Area (km^2)	%	Land Area (km^2)	%	Land Area (km^2)	%	Land Area (km^2)	%
Built-up Area	7.14	2.98	11.75	4.92	18.51	7.75	39.41	16.50
Bare Surface	1.20	0.50	2.84	1.19	2.08	0.87	1.77	0.74
Waterbody	13.69	5.73	32.86	13.76	22.55	9.44	21.09	8.83
Farm Land	92.19	38.60	148.95	62.37	154.16	64.55	146.23	61.23
Forest Land	124.59	52.17	42.41	17.76	41.51	17.38	30.30	12.69
Total	238.81	100	238.81	100	238.81	100	238.81	100

Source: Author's Analysis, 2021

The sizes of built-up areas in Suleja increased from 11.75 km^2 to 18.51 km^2 in 2007 (Table 2). Settlements such as Kwamba, Maji, Diko, and Gwazunu, formally hamlets in 1987, were fully grown into compact/cluster settlements in 2007. The areas of farmlands also expanded in 2007 with new land areas of 154.16 km^2. The rising urban population in 2007 also impacted the forest lands, as 1 km^2 of forest land was lost to anthropogenic activities such as constructing and felling

trees for fuel. A substantial increase in built-up areas was recorded due to the residential pressure from the federal capital territory Abuja. The resultant effect of the increase in built-up areas was a continuous decline in forest lands. In this period (2019), the forest land declined to 30.30 km^2 against the 41.51 km^2 recorded in 2007. It means that 11.21 km^2 of forest lands were lost to the quest for relative flatlands for physical development and the demand for fuel. Slight declines in farmlands were similarly recorded in 2019. The encroachment of built-up areas into farmlands in this period is attributed to the slight decrease in farmlands. The transition matrix analysis (Table 3) reveals that 15.81 km^2 of farmlands were converted to built-up areas between 2007 and 2019.

The horizontal land use land cover of Suleja LGA between 1987 and 2019 is represented in Figure 4. In this figure, built-up areas (Urban land) are illustrated in red; waterbodies appear in blue; forestland is green, while farmland and bare surfaces are represented in yellow and grey, respectively.

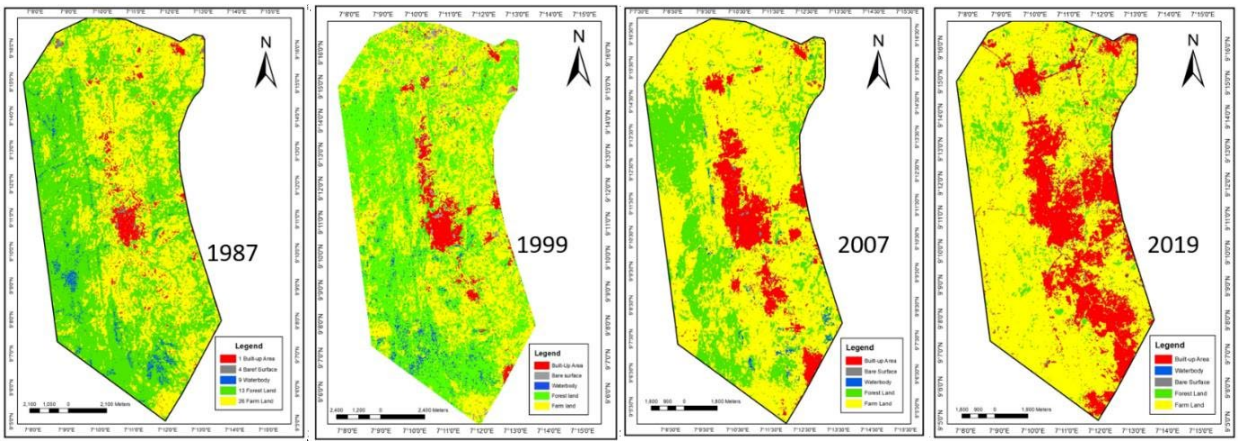

Figure 4 Classified imageries of Suleja between 1987 and 2019
(Source Author's analysis, 2021)

4.1.2. Urban Change Transition

The transition matrix (Table 3) reveals how the different variations in land use and land covers of Suleja have been transforming inwardly and outwardly during the 32 years (1987- 2019). The transition matrix reveals that within the 32-year study periods, built-up areas have had inward and outward changes in their land areas. Though three land uses land cover types (Bare Surface, Farmland, and forest land) were responsible for the urban land within the 32-year study periods, only farmlands had a significant change on the urban land/built-up areas. 30.15 km^2 of farmlands transformed into built-up areas between 1987 and 2019. The transition matrix also revealed progressive transformation from farmlands to built-up areas.

Similarly, farmland also had three land use land cover types influencing its changes, and these land use land covers were forest land, bare surface, and water bodies. Unlike the built-up areas with both inward and outward expansion, farmlands had an outward expansion. Between 1987 and 2019, forest land, water bodies, and bare surfaces with areas of 115.17 km^2, 29.69 km^2, and 2.89 km^2 respectively, were transformed into farmlands.

Farmlands and waterbodies influenced the outward expansion of forest land within the study periods. A total of 19.43 km^2 of waterbodies were transformed into forest lands; in the same vein, a total of 32.73 km^2 of farmlands were changed to forest lands. Furthermore, the transition matrix reveals that of all the land use, land cover types transformed, and only farmlands formed the highest proportion of built-up areas (urban land) changed in Suleja between 1987 and 2019.

Table 3 Urban Change Transition in Four Temporal Periods in Suleja

		1987 - 1999		1999 - 2007		2007 - 2019		Total
'From Class'	'TO Class'	Area km^2	%	Area km^2	%	Area km^2	%	km^2
Forest land	Built-up Area	1.60	0.67	0.19	0.08	0.79	0.33	2.58
	Farm Land	70.39	29.48	12.64	5.29	32.14	13.46	115.17
	Bare Surface	0.47	0.20	0.02	0.01	0.05	0.02	0.54
	Waterbody	23.64	9.90	1.69	0.71	3.08	1.29	28.41
Farmland	Forest land	7.29	3.05	14.08	5.90	11.36	4.76	32.73
	Built-up Area	6.13	2.57	8.21	3.44	15.81	6.62	30.15
	Bare Surface	1.93	0.81	1.26	0.53	1.11	0.46	4.30
Bare Surface	Farmland	0.58	0.24	1.59	0.67	0.72	0.30	2.89
	Built-up Area	0.40	1.17	0.63	0.26	0.81	0.34	1.84

(Source: Author's Analysis, 2021)

4.1.3. Urban Land Change Processes

Based on the Qiuying et al. (2015) urban change intensity model, the corresponding values of <0.10, 0.10 – 0.20, 0.21 – 0.40, 0.41 – 0.70, and ≥0.71 denote very low, low, moderate, rapid and highly rapid respectively. The urban change intensity index of Suleja between 1987 and 2019 reveals a progressive change in the size of urban land. Urban change transcends from the low intensity of urban transformation to a highly rapid intensity of urban change. The moderate and rapid intensity of urban change was experienced in Suleja between 1999 - 2007 and 2007 - 2019, respectively (See table 4), resulting from an increase in urban population and physical development influenced by the State government and Federal government urban policies.

Table 4 Rate of Urban Change and Its Intensity

Year	1987 -1999	1999 - 2007	2007 - 2019	1987 - 2019
Annual Average Rate of Urban Change (%)	5.20	7.54	9.04	3.13
Urban Change Intensity Index	0.16	0.36	0.73	0.42
Category of Urban Change	Low	Moderate	Highly Rapid	Rapid

(Source: Author's Analysis, 2021)

4.1.4. Form of Urban Change in Suleja from 1987 – 2019

The forms of urban change noticed in Suleja local government area within the study period were classified into three forms. These forms are edge expansion, Infill change, and outlying change. The infilling changes in the study area are characterized by new development occurring within a previously developed urban area. The edge changes are the physical development on the fringe or edge of the existing urban area in Suleja LGA. In contrast, the outlying urban changes are the physical development activities that are developed far away from the existing urban area in Suleja LGA. The three forms of urban changes in the study area from 1987 – 1999, 1999 – 2007, and 2007 – 2019 are explained in Figure 5 and Figure 6. The edge expansion is represented in red color, and the Infill change is represented in green color. In contrast, the existing urban area and outlying changes are described in black and yellow, respectively.

The analysis also reveals that urban edge change contributes significantly to the urban change pattern in Suleja LGA from 1987 to 2019. The edge expansion rate of urban change in the study area evolved from 2.66 km² (1987) to 17.03 km² in 2019. Throughout the study periods (1987 -

2019), urban infill change was responsible for a minimum contribution of urban change in Suleja LGA.

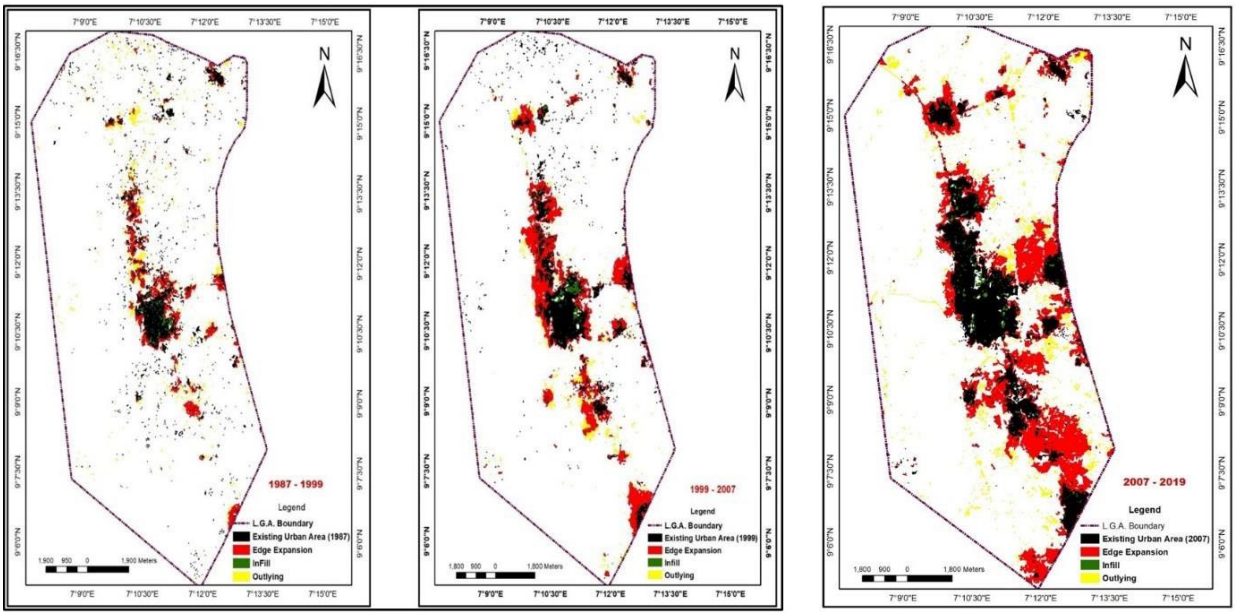

Figure 5 Spatiotemporal Distribution of Urban Change Types in Suleja LGA between 1987 – 1999 and 1999 – 2007 (Source: Author's Analysis, 2021)

At the same time, the outlying forms of urban change were slightly higher than the urban infill change. The outlying urban change decreased in expansion from 1.63 km^2 (1987 - 1999) to 1.43 km^2 (1999 - 2007). Due to the increase in population growth and physical development, an upsurge in the outlying urban change was recorded between 2007 and 2019.

4.2. Drivers of Urban Change in Suleja LGA

The drivers of urban change noted in Suleja LGA were population growth, urban policy, proximity to the FCC, and Neighbourhood quality (Figure 6). These factors influenced the urban change of the study area in various forms, which include increased population growth and density, the dispersed pattern of development, an increase in the spatial extent of the built-up regions, agglomeration of businesses, and improved infrastructures.

Figure 6 Drivers of Urban Change and Its implication

4.2.1. Population Growth and Urban Densification of Suleja Local Government Area

The population growth experienced in Suleja was consequential to the increase in the population of urban residents per unit area of urban land. Table 5 reveals that the population per unit area in Suleja continues to increase simultaneously with the increase in urban lands (built-up areas). The continuous increase in population means that urban demand for space for physical development will increase, and physical development will continue to change the urban form (Dempsey et al., 2010). An increase in population density was also recorded in the study epochs. The increase in population density in Suleja can be used to promote urban sustainability. A high population density encourages recycling, mass public transportation, and local electricity generation (Force & Rogers, 1999). The study also reveals that hotspot areas of population density were concentrated in the core (Magajiya and Hashima A) of the study area.

Table 5 Population Density and Urban Density Index of Suleja Between 1987 and 2019

Year	Population	Percentage of Increase	Population Density	Urban Density Index
1987	53,731		224.99	0.030
1999	184,586	243.54	772.94	0.049
2007	223,942	21.32	923.12	0.078
2019	296,803	32.54	1242.84	0.165

(Source: Author's analysis, 2021)

The population measure of urban growth in Suleja L.G.A. is explained in Figure 7. This Figure reveals that the percentage of urban areas in 1987-1999 was less than the population growth rate. This means that the growth of Suleja within this period was compact. The study also reveals that urban land growth rates were frequently higher than the population growth rate from 1999 - 2007

and 2007 – 2019. This also indicates that Suleja is experiencing a dispersed growth pattern, meaning urban sprawl. The narrative from 1987 – 2019 was quite different from the scenario recorded in the previous epochs. The urban change between 1987 and 2019 shows a tendency of compactness in the form of urban in Suleja. The compactness of the urban change experienced in Suleja between 1987 and 1999 also implies coordinated urban planning.

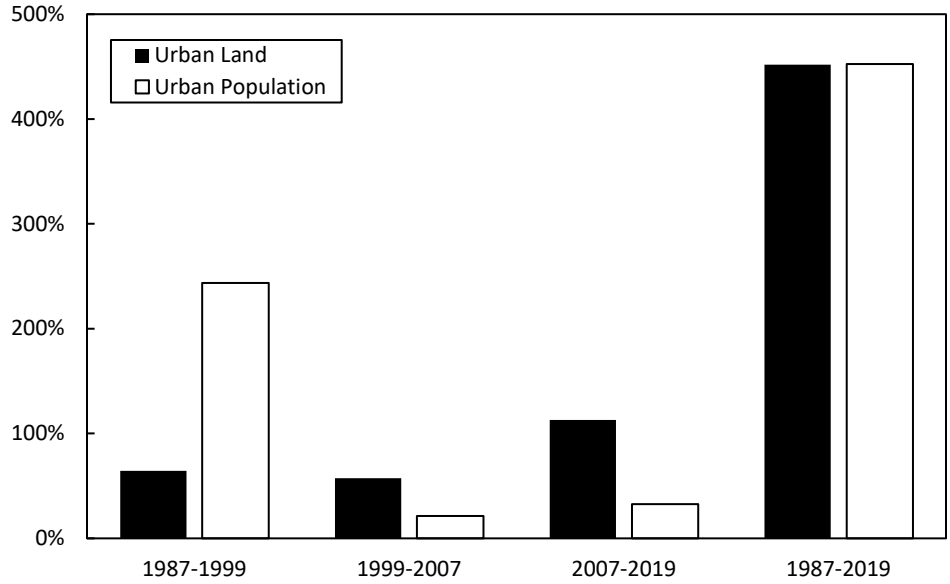

Figure 7 Population Measure of Urban Growth between 1987and 2019

4.2.2. Policy Factor to Urban Change in Suleja Local Government Area and its Implication

The Federal Government policy of 1976 relocating the Federal Capital Territory from Lagos to Abuja changed the morphology of the old Abuja (now Suleja) from an agrarian Settlement into a satellite town of the new capital territory (International Planning Association, 1979). Over the years, the relocation of the FCC from Lagos to Abuja and the relocation scheme of the FCDA have been changing the urban area of the Suleja local government area. The proximity of Suleja L.G.A. to the proposed new Federal Capital Territory made both the Federal Government and the Niger State Government consider the development of Suleja LGA (International Planning Association, 1979; Maxlock, 1979). Since the Federal Government envisaged that Suleja LGA would be a dormitory town and a commercial city with rapid investment opportunities to be derived from the new capital city (Maxlock, 1979). To this effect, the Abuja master plan recommends that immediate and tight development control measures be implemented and that the Federal Capital Development Authority (FCDA) locate its administrative and planning offices in Suleja (Maxlock, 1979).

The construction of phase one of the new capital was momentous to the resettlement of all persons residing in the proposed capital city and settlements within a 5 km radius of the proposed Federal Capital City by the FCDA (IPA 1979; Maxlock, 1979; The Center on Housing Rights and Evictions Social and Economic Right Action Center, 2008). The resettlement scheme by the FCDA influenced the population growth of Suleja; in 1981, the FCDA resettled 11,000 persons in two newly built villages (Wuse and Jiwa) in Suleja Local Government Area (Maxlock, 1979; CHRESERAC, 2008). The FCDA further drew a plan to resettle eight more villages with an estimated population of 18,000 out of the proposed Federal Capital City (FCC) in the Suleja local government area. The final relocation of the Federal Capital City from Lagos to Abuja in 1991 led to an influx of people from other parts of the country to settle at Suleja L.G.A. due to the

envisaged business opportunities and the high cost of accommodation within the new Federal Capital Territory (Buba et al., 2016).

In a bid to keep the sanctity of the master plan for the new Federal Capital Territory, 49 more settlements were relocated out of Abuja between 2003 and 2007 (CHRESERAC, 2008), and some of the inhabitants of these settlements relocated to Suleja L.G.A. To address the rapid urbanization in Suleja due to the increase in population, the Niger State Government prepared an Integrated Development Plan in 2012 to make Suleja L.G.A. a smart city (NSUSP, 2012). The initiative of the Integrated Development Plan is yet to be achieved by the State government as of 2021.

The planning and development of Suleja were enhanced with the initiation of the Niger State Development Blue Print (2019 – 2023). The Development Blue Print proposed that major roads in Suleja should be landscaped and beautified with drainage systems. Other features of the Development Blueprint include installing solar streetlights, implementing social housing, developing new towns along Suleja, and reviewing the Suleja Masterplan of 1987. As a result of the obsolete policy documents (Niger State Regional Development Plan 1979 – 2000, Suleja Masterplan 1987 - 2007), Suleja Local Government Area continues to grow unguided. The chronological urban development policies of Suleja are presented in Figure 8.

Before the 1976 relocation policy of the Federal Government of Nigeria moving the Federal Capital City from Lagos to Abuja, the only industry and commercial establishment found in Suleja was the Ladi Kwali pottery center (or Abuja pottery center), which was established in 1951. When the relocation policy was made, the Ladi Kwali pottery center was the only establishment in Suleja L.G.A. that could employ at least 57 workers (Maxlock, 1979). The initiation of the Abuja masterplan (1979), the Regional Development Plan of Niger State (1979), and the masterplan of Suleja L.G.A (1987) prompted an increase in the rate of investment, speculation, and in-migration into Suleja L.G.A.

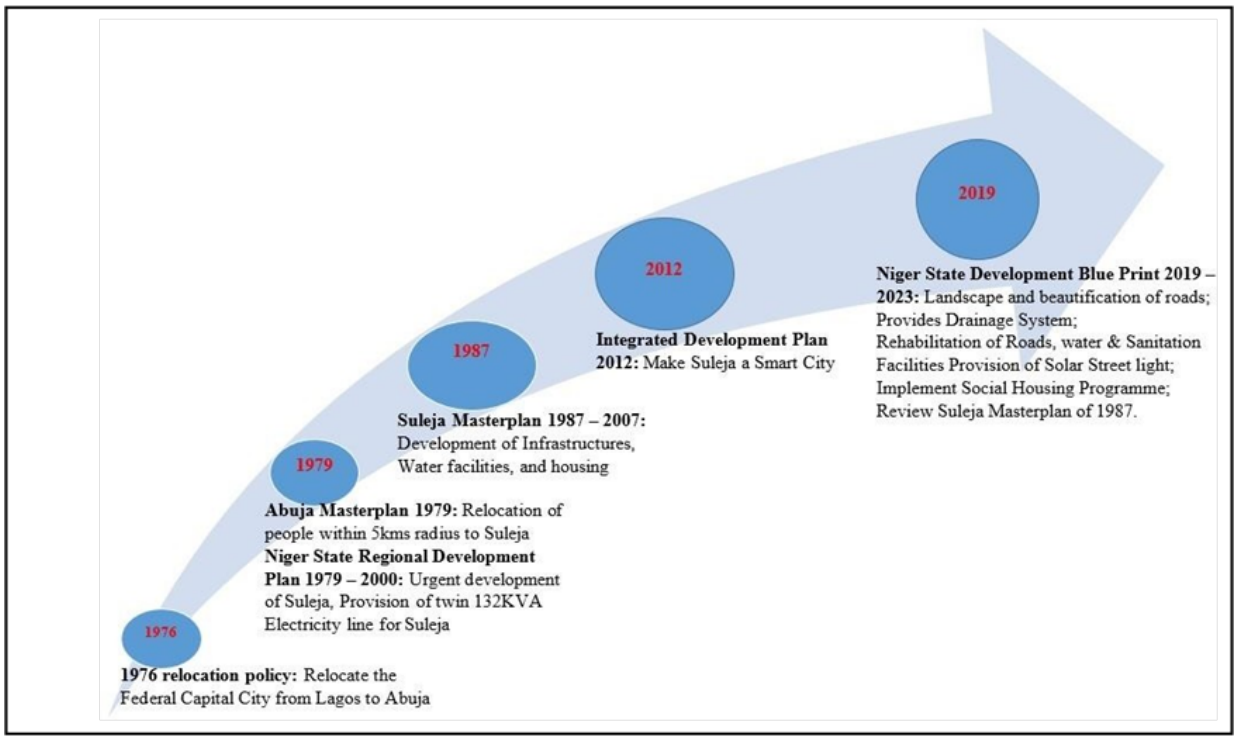

Figure 8 Urban policies in Suleja from 1976 – 2019

Table 6 explains the changes in small, medium, and large enterprises in Suleja L.G.A. due to the influence of the Federal Government of Nigeria and the Niger State urban development policies/plans. The eventual relocation of the Federal Capital City from Lagos to Abuja in 1991 by the Federal Government had a positive effect on the socio-economic development of Suleja L.G.A as small, medium, and large enterprises agglomerated in the region. The table further explains that between 1987 and 2019, the agglomeration of small, medium, and large enterprises increased significantly. An increase of 333.73% was recorded in the growth of the small, medium, and large enterprises in the Suleja Local Government Area.

In response to the 1979 relocation policy of the Federal Government of Nigeria (shifting of the new Federal Capital City to Abuja from Lagos), the Niger State Government proposed a twin 132KVA line in the Niger State Regional Development Plan of 1979 to boost the electricity Supply in Suleja L.GA. The twin 132KVA was offered to run from the Shiroro hydropower lines proposed in the Niger State Regional Development Plan of 1979.

To meet the increased electricity demand, the capacity of the sub-station was upgraded in 2016 with additional new transformers of 2X60MVA, 132/33KV. The two new transformers have a load capacity of 48Mw each, which increased the Suleja L.G.A. sub-stations capacity from 66MW to 162MW (Emenike, 2019). Considering the proximity of Suleja L.G.A. to the new Federal Capital City (Abuja), the Suleja L.G.A. masterplan of 1987 envisaged that Suleja L.G.A. would be a dormitory town for many civil servants who would be working in Abuja. The Suleja L.G.A. master plan (1987) proposed housing estates closer to the new Capital City.

Table 6 Agglomeration of Small, Medium, and Large Enterprise in Suleja Local Government Area between 1987 and 2019

Small, medium, and large enterprises	**Suleja 1979**	**Suleja 1987**	**Suleja 2019**
Transport Company	-	-	10
Information Technology	-	-	36
Agricultural Mills	17	17	24
Major Argo Processing Industries	-	-	3
Hotels and Restaurants	-	-	33
Health/Pharmacies	18	18	124
General Hospital	1	1	1
Educational	178	186	490
Building Construction/Block Industries	2	2	33
Bakery and Confectioneries	1	1	35
Manufacturing	20	21	40
Wholesale and Retail Trade	-	2	224
Repair of Home Gadgets	-	2	11
Repair of Vehicles	-	1	10
Micro Finance Banks	-	-	3
Real Estate firms	-	-	3
Commercial Banks	-	1	13
Total	237	252	1093

(Source: Niger State Regional Development Plan, 1979; Suleja Masterplan, 1987; Niger State Bureau of Statistics, 2011; Niger State Bureau of Statistics, 2012; Niger State Ministry of Education, 2021; Niger State Small and Medium Business Enterprises, 2021; Author's compilation, 2021.)

Due to the rising urban population and housing deficit in Suleja L.G.A. (Ojo, 2021), the Niger State Government initiated the first housing estate (Zuma Housing Estate) in 2001, 10 years after the relocation of the new Federal Capital City. Though the Zuma housing estate was meant to

have been completed in 2002 (Yashim, 2001), findings reveal that only 80 percent of the houses were completed in 2019.

In the same vein, the Federal Government of Nigeria and the Niger State, in collaboration with the private sector, initiated the Zariawa housing estate (1000 housing units) in Suleja L.G.A. This project was to ease the housing burden faced by civil servants who resides in Suleja (Ganagana et al., 2016; Mosadomi, 2014). The finding reveals that only 10% of the housing units in Zariawa Estate were completed before the project was abandoned

This study further reveals that in the bid for the Niger State Government to transform Suleja L.G.A. into a modern urban city with smart homes following the Masterplan and the Niger State Development Blue Print. The Niger State government, in collaboration with private sectors, embarked on 279 and 1,220 units of housing estate at Rafin-Sayin and Dikko, respectively.

The study reveals that before the 1987 Masterplan of the Suleja local government area, only 10.97 km^2 of tarred roads were found in the urban area, while other roads were graded tracks. In preparation for the new Federal Capital City (Abuja) relocation, the Niger State government improved the road infrastructure in Suleja L.G.A. by constructing an additional 41.19 km^2 roads in the study area. As a result of the increasing urban population and urban change in Suleja L.G.A., an additional 20.23 km^2 roads were constructed in 1997. To ease traffic challenges due to the rising urban population in the Study area in 2013, the Niger State Government, in collaboration with the World Bank through the Rural Access Mobility Project II (RAMP II), constructed an additional 10.56 km^2 roads in Suleja L.G.A (Niger State Ministry of Works, 2014). Though large percentages (84.94%) of the roads in Suleja LGA are still graded tracks, this study further reveals that Suleja L.G.A. has significantly increased road construction from 10.97 km^2 (1987) road within the urban area to 82.95 km^2 (2019). The increasing number of tarred roads has influenced the pattern of urban change in Suleja L.G.A. between 1987 and 2019.

4.2.3. Proximity to the Federal Capital City

The location and proximity of Suleja LGA prompted the Niger State government to prioritize the physical development of Suleja, among other local government areas in the State (Maxlock, 1979). The location of Suleja also encouraged the Federal Government of Nigeria to designate the local government as a satellite town to the new FCC (Benna & Benna, 2017; International Planning Association, 1979). Obiadi et al. (2019) also believed that the proximity of Suleja to the Federal Capital City brought stability to the town in socio-economic activities and physical development. The proximity of Suleja to the FCC influenced land speculators, developers, and investors to start planning on maximizing the benefits accompanying the new Federal Capital (Maxlock, 1987). The investors' approach encouraged the establishment of various industries in Suleja, which in turn provided economic opportunities for the residents of the LGA and other neighboring states. The proximity of Suleja has also encouraged the Niger State Government to develop various low-cost housing. The development of housing by both State government and Private investors eases the housing burden of the public servant who works in Abuja (Alfred et al., 2016).

4.2.4. Neighborhood Quality as a Factor of Urban Change in Suleja LGA

The mean weighted index was used to analyze the neighbor quality of the study area. Five sets of indexes were created, ranging from 1.00 – 5.00, to represent each scale. Indexes 1.00 – 1.80 was used to describe the "Very Poor" opinion, 1.81 – 2.60 was used to denote "Poor" opinion, 2.61 – 3.40 means "Average" opinion. While the indexes of 3.4 - 4.20 and 4.21 – 5.00 represent "Good" and "Excellent" opinions, respectively. The analysis reveals that commercial activities

in Suleja L.G.A. had a "Good" response. While accessibility, social amenities, recreational facilities, aesthetic qualities, and green spaces (organized open spaces) responded poorly.

Table 7 further reveals that perceived safety, quietness, and healthcare centers recorded an average perception due to the influx of people in the study area. The "Good" response received in commercial activities on a Likert scale explains that commercial activities in the study area thrive due to its proximity to the Federal Capital City (Ejaro & Abdullahi, 2013).

Table 8 explains the factors the residents of Suleja L.G.A. perceived to have influenced urban change within the study period. The study reveals that 53.02% of the respondents, which constitutes the highest percentage, thought that economic opportunities are a strong factor that influences urban change in Suleja L.G.A. Proximity to the Federal Capital City, Abuja, was also noted as a strong factor influencing urban change in Suleja L.G.A., as this option is ranked second in the order of response. Table 8 also reveals that 36.24% (3rd rank) of the respondents perceived that the social status of some residents had influenced urban change in the study area.

Table 7 Neighborhood Quality/Characteristics of Suleja L.G.A

Neighborhood Quality / Characteristics	Very Poor	Poor	Average	Good	Excellent	Total	Mean	Decision
Recreational Facilities	48	92	126	52	0	318	2.13	Poor
Aesthetic Quality	37	102	141	56	0	336	2.26	Poor
Accessibility	21	92	165	108	0	386	2.59	Poor
Perceived Safety	15	108	159	108	0	390	2.62	Average
Green Spaces	47	118	96	44	0	305	2.05	Poor
Quietness	27	68	162	132	5	394	2.64	Average
Market/Shopping Centers	1	20	150	348	5	524	3.52	Good
Social Amenities	19	104	156	104	0	383	2.57	Poor
Health Care Center	5	30	174	276	10	495	3.32	Average

(Source: Author's Field Survey, 2021)

Low rent was argued to be a factor influencing urban change in Suleja L.G.A. by 24.16% of the sample respondents who believed that more civil servant in Abuja resides in the urban area of Suleja. Religious belief, early marriage, and institutions of learning were other factors that were believed to have influenced urban change in Suleja L.G.A within the study period. These factors were ranked 7th, 8th, and 4th, respectively.

Table 8 Perceived Factors Responsible for Urban Change

Options	Frequency	Percentage	Rank
Low rent	36	24.16	6
Economic Opportunities	79	53.02	1
Early marriage	19	12.75	8
Large Household size	43	28.86	5
Religious Belief (Polygamy)	29	19.46	7
Social Status	54	36.24	3
Institutions of Learning	45	30.20	4
Proximity to the Federal Capital Territory	71	47.65	2

(Source: Author's Field Survey 2021)

5. DISCUSSION

The rapid magnitude of changes recorded in Suleja between 1987 and 1999 is attributed to the relocation of the Federal Capital City (FCC) to Abuja in 1991, which was instrumental to the commencement of various physical development activities in Suleja. The rapid urban change of Suleja LGA can also be ascribed to the influx of people who have come to Abuja in search of economic opportunities and 'public servants' who commute daily from Suleja to Abuja due to affordable house rent (Auta, 2019; Buba et al., 2016). Studies (Abubakar et al., 2021; Buba et al., 2016) have confirmed this affirmation that due to the proximity of Suleja L.G.A. to the New Federal Capital City (Abuja), a momentous urban change has been witnessed in the study area.

Those farmlands formed the highest proportion of land use land covers transformed into built-up areas (urban land) between 1987 and 2019 indicates that as the population increases, needed for physical development. Thus, farmlands are most accessible to the residents for physical development. This result was similar to Shifaw et al.'s (2018) findings, which reveal that farmlands were the major contributor to urban lands amidst an urban change in the province of Pingtan in China. Between 1987 and 2019, a total of 30.15 km^2 of farmlands were converted into built-up areas.

The pattern/forms of urban changes in Suleja LGA reveal that edge and outlying expansions encourage a more dispersed pattern of urban change. These findings affirm He et al. (2018) assertion that edge and outlying changes are the main contributors to dispersed growth in an urban area. Since edge expansion is more dominant than the urban infill change in Suleja LGA, the implication is that the urban change of Suleja LGA is characterized by urban sprawl. Studies by Gong et al. (2018), Jiao et al. (2018), and Yu & Zhou (2017) affirm this result. The dispersed growth of Suleja is also evident in its Outlying (leapfrogging) urban form of urban change. The sprawling nature of Suleja from these two epochs (1999 – 2007, 2007- 2019) was also affirmed in the analysis of the forms of urban change in Suleja (See Figure 5 – 6).

This analysis also asserts the conclusion of Al-Sharif (2017) that when the expansion rate of built-up areas/ urban lands is constantly higher than the population growth rate, then high dispersion emerges, which is an indicator of higher urban sprawl. On the other hand, the urban pattern of 1999 – 2007 and 2007 – 2019 also indicates chaotic urban planning. According to Soffianian et al. (2010), chaotic urban planning occurs when the percentage of urban areas exceeds the rate of population growth.

The low urban density index recorded in Suleja between 1987 and 2019 reveals that the urban area of Suleja is not growing in a coordinated manner. This result asserts the findings of Abdullahi et al. (2017); Abdullahi & Pradhan (2017); Norzailawati et al. (2014), who opined that a high urban density index indicates urban sustainability and Smart growth, which encourages walking and cycling while low urban density areas indicate a scattered and a decentralized urban form which is not a sustainable form of urban growth. The urban density indexes recorded in Suleja ranged from 0.030 to 0.165.

Between the study epochs (1987 to 2019), Suleja LGA has had three different development policy documents (Suleja Masterplan, Integrated Development Plan, and Niger State Development Blue Print). Though the Integrated Development Plan was never implemented, the outdated Masterplan and Niger State Development Blue Print still enhanced the development of the study area. In the perceived factors responsible for urban change in Suleja, economic opportunities ranked 1st, meaning economic opportunities are a strong factor influencing urban change in Suleja L.G.A. This perception affirms the findings of Liang et al., 2018; Lu et al., 2013 that

economic activities affect growth and changes in an urban area. In a study conducted by Mawoli (2021) on the analysis of Niger State's business environment for investment attraction opportunities, Suleja was noted to have 40% of the functional industries in the State. It implies that economic opportunities actually progress in Suleja Local Government Area.

6. CONCLUSION

This study adopted remote sensing and GIS tools to quantitatively analyze the processes of urban change in Suleja from 1987 to 2019. During the 32 years of the study period, a rapid category of urban change was witnessed in Suleja, and this led to an outlying urban form characterized by a dispersed pattern of physical development. The urban change in Suleja within the 32 years study period was driven by population growth, urban density, and the government's urban policies. Further studies can be done in urban change and simulation of future urban forms. This study, therefore, recommends that the Niger State Government should review the obsolete Niger State Regional Plan and the Suleja Master Plan to achieve the anticipated Suleja smart city project envisaged. Amidst the rapid urbanization experienced in Suleja, the Niger State Urban Development Board should enforce articulated urban planning to check the problems of uncoordinated urban planning arising from the dispersed nature of physical development. Abandoned housing estates and other ongoing housing estates in the LGA should be encouraged to be completed in the proposed Integrated Development Plan of Suleja, as this will help solve the problems associated with housing and low urban density.

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THE CONCEPT OF PERMEABILITY ON THE NEIGHBORHOOD SCALE

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ABSTRACT

Urban sprawl is rapidly expanding in the outskirts of Jakarta city in Indonesia, resulting in a patchwork of urban areas. Unlike many walkable cities in European Countries that have long embraced the pedestrian culture, Jakarta and other developing cities have prioritized private vehicle-oriented development, leading to mixed urban forms. According to statistics data, over 16.5 million motorcycles were registered in Jakarta, and 62.3% of Jabodetabek commuters use them in 2022. This study recognizes the permeability of neighborhood scale concerning using motorcycles to support daily mobility. This narrative qualitative research investigated permeability regarding the legibility, variety, and perceptual aspects. In addition, the case study was investigated to explore the concept of permeability at the neighborhood scale, highlighting the role of motorcycles in supporting it. The findings show that the permeability on a neighborhood scale relates to the negotiation space between motorcycles mobility and residents, including street vendors. Despite the significant impact of motorcycles on the city's configuration, stakeholders involved in urban space interventions have yet to fully recognize the importance of addressing motorcycle-related issues, including safety and liveability.

Keywords: Motorcycle; Neighborhood; Permeability

1. INTRODUCTION

Urbanization is one of the reasons many cities have experienced an expansion of urban areas and an increase in the number of residents in the city. The population of Jakarta has almost doubled from 6.5 million in 1980 to 10.6 million in 2021 and is predicted to be 11.4 million in 2035 (BPS, 2023). The city's very high cost of living means that many people tend to live in the suburbs at a lower cost. Bogor, Depok, Tangerang, and Bekasi cities are the best choice to live in because the prices are relatively affordable. The rapid development in the city's outskirts generated a heterogenous characterized by mixed urban configurations, regular and irregular ones. On the city's outskirts, the typical spreading neighborhood begins from villages that have existed for a long time and have organically transformed continuously until now.

This fact also results in an increasing number of commuters, who have been traveling between the suburbs and the city center every day. Several modes of mobility have been present in Jakarta, but in the periphery areas, transportation choices are limited and need to be integrated. Difficulties in accessing public transportation, for example, bus and rail-based transportation, make people choose other transportation such as private cars, motorcycles, and informal transportation such as ride-hailing (Nishikawa et al., 2019). In this regard, motorcycles offer a popular solution in terms of affordable price and practical reasons.

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The motorcycles provide levels of mobility that other modes have been unable to match, as they use much less roadway capacity than automobiles. In 2021, the number of motorcycles in Jakarta will be more than 16.5 million (BPS, 2022). The various types of motorcycles at affordable prices and easy loans increase motorcycle ownership annually. Moreover, the number of commuters from the Bodetabek area was 1,255,771 people, of which 63.3% used motorcycles and only 26.9% used public transportation (BPS, 2019).

Along with technological innovations such as the emergence of "*Ojek"* or motorcycle taxi based on ride-hailing applications and the progress of motorcycles into electric vehicles, people are increasingly dependent on these two-wheelers' motorized modes. In addition, the motorcycle offers convenience and has also eliminated the habit of walking, especially from public transportation points to main destinations (Soelaiman et al., 2018). The motorcycle's ability to easily accelerated and manoeuver enables the drivers to shortcut through the alleys of urban villages or *kampung*. It is the mainstay of motorcyclists in speeding up their mobility trips. The role of alleys within the *kampung* is significant for supporting mobility. In the era when everything should be fast, roads and alleys are the backbones of permeability.

The concept of permeability was introduced by Kevin Lynch as the space configuration easily reached from one point to another. Permeability is essential as part of legibility (Lynch, 1961). To present a good city form is to have a permeable spatial pattern to facilitate accessibility and maximize connectivity (Lynch, 1984; Talen, 2002). Permeability is a compositional property, referring to the degree to which an area of a two-dimensional plan is 'absorbed' by accessible space as it relates to distance and area available for circulation (Marshall, 2004). Permeability emphasizes the ease of movement and the many choices of routes between two points. Therefore, permeability is related to the capacity to move and the potential to interact in urban spaces (Pafka & Dovey, 2017). In addition, permeability allows ease of movement and avoids disconnection of the urban network, which is generally considered a positive attribute of urban design schemes (Melia, 2012). Permeability is a visual quality and behavior characterized by sight and movement (Silavi et al., 2017). Three aspects affect city permeability: namely, blocks, roads, and hierarchical configuration (Puwantiasning et al., 2022).

Most of the research on permeability topics emphasizes walkability factors or the ability of an area to provide such access, connections, horizontal connectivity, and the arrangement of blocks or roads that are suitable for walking (Lee & Talen, 2014; Stangl, 2015). The concept of permeability in this study is slightly different from cities in Europe and Western countries. The city configuration in Europe is primarily regular, and there are restrictions for motorized vehicles, especially motorcycles. The motorcycle industry in Europe in 2022 sold only 1.56 million units, ranked as the highest number for the last 15 years (MCDTeam, 2023). Compared to Indonesia, this number is only one-third of the total as the country has 5.22 million units in the same year (AISI, 2023).

Every year, the increasing number of motorcycle owners in Jakarta has significantly changed the city's configuration. This research wants to answer the question of motorcycles' role in supporting the city's permeability. The research aim is to enrich the idea of permeability, which is not limited merely to walking but also motorcycling. Traveling in large blocks was previously impossible without motorcycles, neither by food nor automobiles, because it was too far away on foot but too narrow for cars to pass through. Motorcycles make it possible and make the distance closer and mobility faster since the alleys turn into shortcuts for motorcyclists.

This study emphasizes space's permeability that supports mobility on a neighborhood scale. The case study of this research is the area of Cakung East Java. The area has different types of neighborhoods: (1) vertical housing; (2) formal/organized landed houses; (3) informal /organic landed houses. Since the area has a low coverage of public transportation services, most dwellers

use motorcycles as their main mode of transportation. This research aims to understand the permeability of neighborhood scale in relation to using motorcycles to support daily mobility.

2. LITERATURE STUDY

Permeability is one of the essential concepts in urban design. It refers to the ease of movement of people and vehicles within an urban environment. Permeability measures how easily people and vehicles can move from one point to another. Lynch (1961) emphasized the importance of street network management in urban development. The network should have links that are easily accessible and efficient and connect different areas within the city. A well-connected road network can increase permeability within a city because it allows easier accessibility and movement for city dwellers (Lynch, 1984). It can improve connectivity between regions and increase ease of access to important places such as commercial centers, offices, and public facilities. It also can strengthen social and economic ties within cities. People familiar with the environment recognize its permeability with a close dependency on spatial structural properties such as blocks, paths, and hierarchical layouts (Silavi et al., 2017).

In addition, permeability is one of the categories needed to produce a responsive urban environment (Bentley et al., 1985). Physical permeability extends to an environment that permits people to choose how to access it from one location to another and offers diverse ways to get from one location to another to determine a public space's permeability. However, these alternatives should be observable; only familiar users can use the space. Therefore, visual permeability is also crucial. Both physical and visual permeability depends on how the public space network divides the environment into blocks. Permeability is related to connecting pathways indicating whether the sight or movement is good (Puwantiasning et al., 2022).

From observation in New York, Jacobs (1961) discusses how to make a lively, safe, and multifaceted neighborhood. The small blocks of permeability relate to creating public spaces that can increase openness and connectivity between areas within the city. In the same city, Sitte (1980) criticized the monotony of regular grids. The tiny blocks have the drawback of limiting the possibilities for density, private open space, and frontage activation. Copenhagen is the city that became the setting for Gehl's (1987) writing which accentuates the concept of sustainability, including human, economic, and environmental dimensions. The concept of permeability is evident with connected cycle paths and an integrated public transport system. The well-connected street is part of the social fabric, part of town, and the lives of all the people who live and move around it (Alexander et al., 1977).

The permeability concept on a neighborhood scale also relates to traffic. In San Francisco, Appleyard (1981) discusses traffic conditions that significantly influence life on the street and the social relations between users. Bill Hillier, an architect, and urbanist from England, writes that permeability is related to the ability of the road network and buildings within the city to flow the movement. The space syntax approach studies the connection between social life and urban structure (Hillier & Hanson, 1984). The objective is to quantify data to the point where computer programs can use it to calculate the probability that people will walk in one direction to another in current and future conditions. Spatial syntax research examines the connections between topological measures of urban networks like integration and intensity (Hillier & Hanson, 1984).

In transit-oriented development, permeability emphasizes the area that can be reached by walking or cycling: The area's orientation and building masses ought to facilitate short-distance trips (Cervero, 2009). The quality of the urban fabric, based on the human scale, is a key driver of place value permeability, diversity, and the capacity to evolve. Increasing road connectivity will increase permeability opportunities for various modes of transportation. Permeability relates to the capacity to move and the potential to interact in urban space to the extent how reconciling

motor traffic with a neo-traditional system of urban design, emphasizing streets and their patterns (Marshall, 2004). Restricting vehicular access in favor of pedestrians through filtered permeability directly slows down traffic and increases street safety while redefining space for alternative uses. Hence, alternative access should be made for cul-de-sac areas during disaster evacuation to increase permeability (Rosyidah et al., 2022).

The permeability theory originated in several major European and North American cities in the 20th century, including London, Paris, Copenhagen, New York City, and Amsterdam. The idea of permeability, on the other hand, has been the subject of discussion in a variety of contexts in cities all over the world, including Asia and developing countries, alongside innovation in both theory and practice. The unique social, economic, and political conditions may be why cities in Asia and developing nations have slightly different meanings of permeability from cities in Europe and North America. In Asia, cities often experience rapid and dense growth. In addition, problems such as social inequality, poverty, and political instability can affect the application of the concept of permeability. In some cases, there may be other priorities for stakeholders and communities.

The city form tends to be heterogeneous, has inadequate transportation systems, and the top market for motorized vehicles makes people living in cities in Southeast Asia, especially Jakarta, choose motorbikes as a practical choice for mobility. The motorcycle phenomenon helps in applying the concept of permeability. However, it needs to get more attention related to increasing the safety and comfort of users and public spaces. Morphogenetic studies have demonstrated that in urban centers with block sizes larger than one-hectare, new streets and arcades frequently result in gradually fragmenting these blocks into smaller ones over time (Siksna, 1997). Based on observations of Western cities, normative approaches typically define *good permeability* as a block length of 60 to 90 meters (Whyte, 1980), with a maximum of 120 meters (Jacobs, 1961). However, recent research from various forms of blocks such as chamfered blocks, square blocks, elongated blocks, large blocks, and heterogenous mixes of blocks found that the heterogeneous mix type blocks are highly permeable. However, half the area is consumed by a single impermeable block (Pafka & Dovey, 2017).

3. METHODS

This study used narrative qualitative research to understand the themes, the patterns, and the broader meanings of the phenomena of motorcycles in the case studies. This study was supported by a theory related to permeability and urban morphology to understand permeability on a neighborhood scale. The permeability has been investigated regarding its physical, functional, and perceptual attributes (Yavuz & Kuloğlu, 2012) —the influence of permeability analysis on motorcycle mobility in the neighborhood.

To explore theories related to permeability, some journals and book articles were studied using keywords such as "permeability", "neighborhood", and "mobility". This study also observed the physical aspects of the case study through field observation of elements of urban form. Online observations through Google Street View were used to obtain secondary data. These secondary observation techniques were carried out to find initial findings before the field survey of the case studies for deeper exploration. Field observation techniques were used to obtain data before analyzing the spatial configuration of the case studies. Field observations occurred on weekdays and weekends in the morning, afternoon, evening, and night, especially during peak hours. Interviews were conducted with some essential actors, such as neighborhood leaders from RW 09 Penggilingan (*Rukun Warga* or Citizens Associations), LMK RW 09 Penggilingan (*Lembaga Musyawarah Kelurahan* or Sub-district Consultative Council), PKK members, and *ojek* drivers.

The researchers asked open-ended questions such as length of stay, mobility preference mode, and mobility experience.

Furthermore, the analysis employed an overlay technique to process the data mapping derived from field observations and interview descriptions. Ultimately, the discussion revolves around permeability and city morphology concerning motorcycles as a mode of mobility.

4. RESULTS AND DISCUSSION

Jakarta represents a city that morphologically consists of both formal and organic forms. On a neighborhood scale, Cakung district was chosen as a case study because it is located on the outskirts of Jakarta and specifically shows a tendency to develop into heterogeneous forms (see Figure 1). In addition, the area of Cakung is the largest district with the largest population in East Jakarta (BPS, 2022). The domination of residential land use and the unavailability of reachable public transportation also makes Cakung meets the criteria as the case study. This case study provides broader insights into the spatial configuration of the neighborhood and its relation to the permeability of the motorcycle as the mode of transportation.

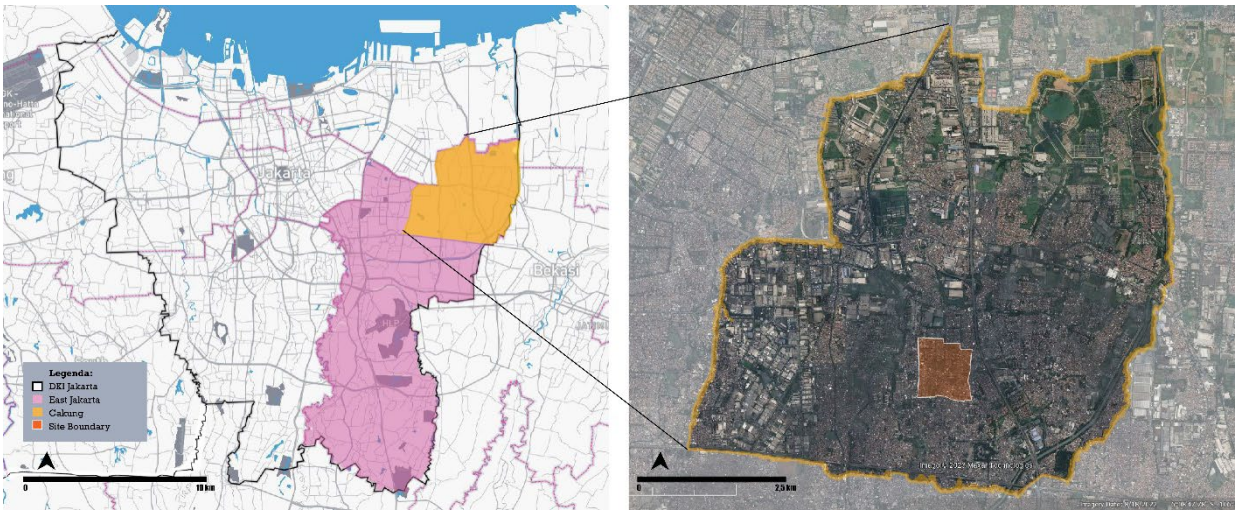

Figure 1 Case Study Context in Cakung, East Jakarta, DKI Jakarta
Source: Map was adapted from Google Maps and developed based on authors' survey

Research on urban permeability primarily focuses on cases in economically advanced countries, with rare instances in developing nations. Urban morphology and permeability analysis was carried out to understand the physical structure of the neighborhood and how these structures are connected to the surroundings. The first part will discuss the morphological aspect on a broader scale. It is a unified region that distinguishes it from surrounding regions. Moreover, it showed how the urban landscape is stratified, resulting in a hierarchy of morphological regions that can be represented in a composite map with regions arranged in different ways (Oliveira, 2016). This hierarchy reflects the distinctive urban character remains of previous periods. The second part analyses the development process of streets, plots, and buildings within, and the movement of motorcycle mobility relates to resident and their space negotiation surrounding the study area. The progressive abstraction of network structure—from composition (geometry) to configuration (topology) to the constitution (hierarchy)—is elaborated and studied in a constitution-led approach for analysis (Marshall, 2004).

4.1. Areas Morphology

From the map archive issued by Leiden University in 1914-1940, the case study area was previously villages, swamps, fields, and paddy fields. Villages develop organically, unplanned, and have irregular patterns (see Figure 2). From 1940-1980, there was no significant development in the study area because most of the urban developments at that time were in the northern region, specifically Tanjung Priok and Pasar Ikan; east region, including Cililitan, Rawamangun; Kebayoran Baru, Cipete, Kuningan and Tebet in the south; west region namely Tomang, Slipi, and Palmerah; as well as centers region Cempaka Putih and Sumur Batu, also known as Kemayoran (Sedyawati et al., 1986; Silver, 2007). It is in line with the findings of field observations and interviews, which indicated 3 (three) significant changes in the study area:

1. Industrial development around Cakung attracted developers to invest and develop residential settlements. In 1982, a cluster of landed houses was built by Aneka Elok real estate, known as Komplek Pinus Elok (Maria et al., 1996).

2. The development of vertical residential types built by the local government, such as *Rusun* (apartment) Pinus Elok Blok A and Blok B in 2007 and Rusun Pulo Gebang Penggilingan in 2017.

3. The local government built arterial roads along Jalan Penggilingan Raya and Jalan Komarudin Lama, significantly transforming the Cakung area.

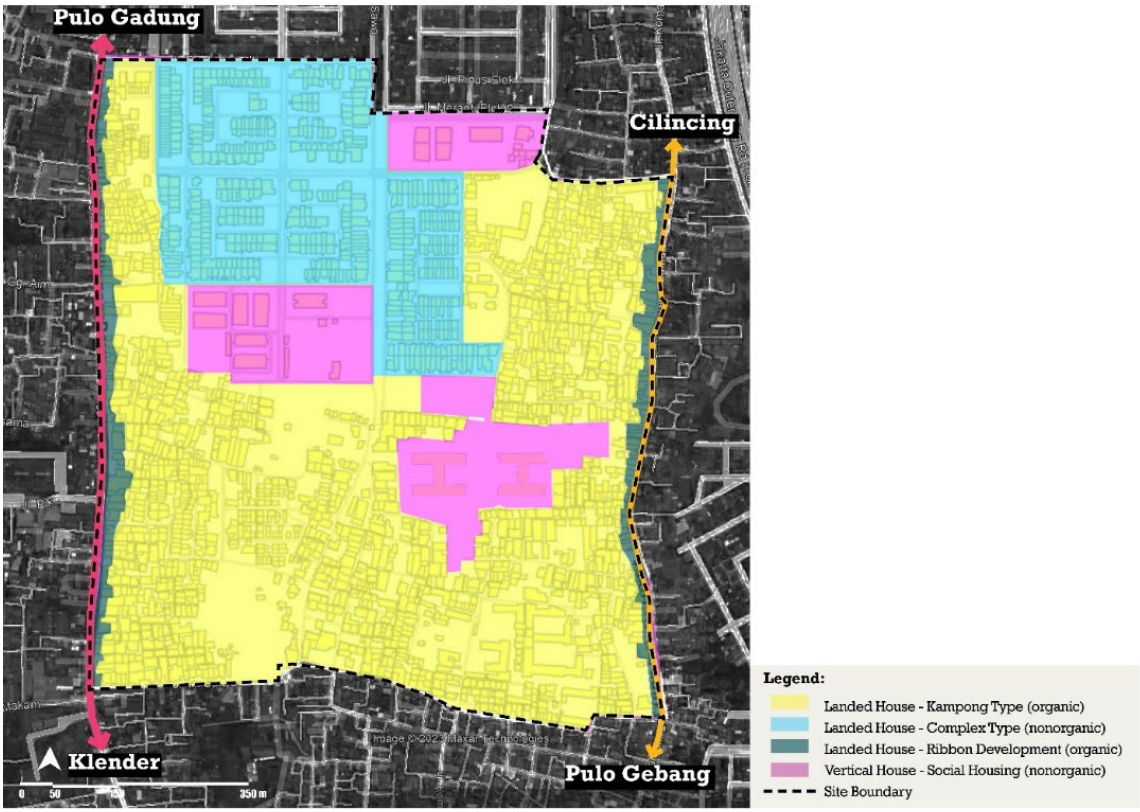

Figure 2 Spatial Grouping of Neighborhood Based on Morphological Region (Historical- Geographical Structures)
(Source: the map was adapted from Google Maps and developed based on the authors' survey)

4.2. Road Structure

Based on field observations, there are five types of roads: (1) arterial roads, 92) local roads, (3) neighborhood roads, (4) alleys, and (5) dead-end alleys (cul-de-sacs) (see Figure 3). Arterial roads

connect the neighborhoods to the broader urban transportation system. The arterial road is Jalan Penggilingan Raya which stretches in a north-south direction. Based on the old map, in the 1940s, this road was an unpaved village street, only 2-4 meters wide. Now Jalan Penggilingan Raya has broadened into 9 meters width, and it is enough to accommodate cars and even trucks and generate heavy traffic. When the government established Transjakarta routes, the roads became increasingly important as they linked the surrounding area to other parts of Jakarta. Now, offices, shops, and warehouses are lined along these roads (see Figure 3).

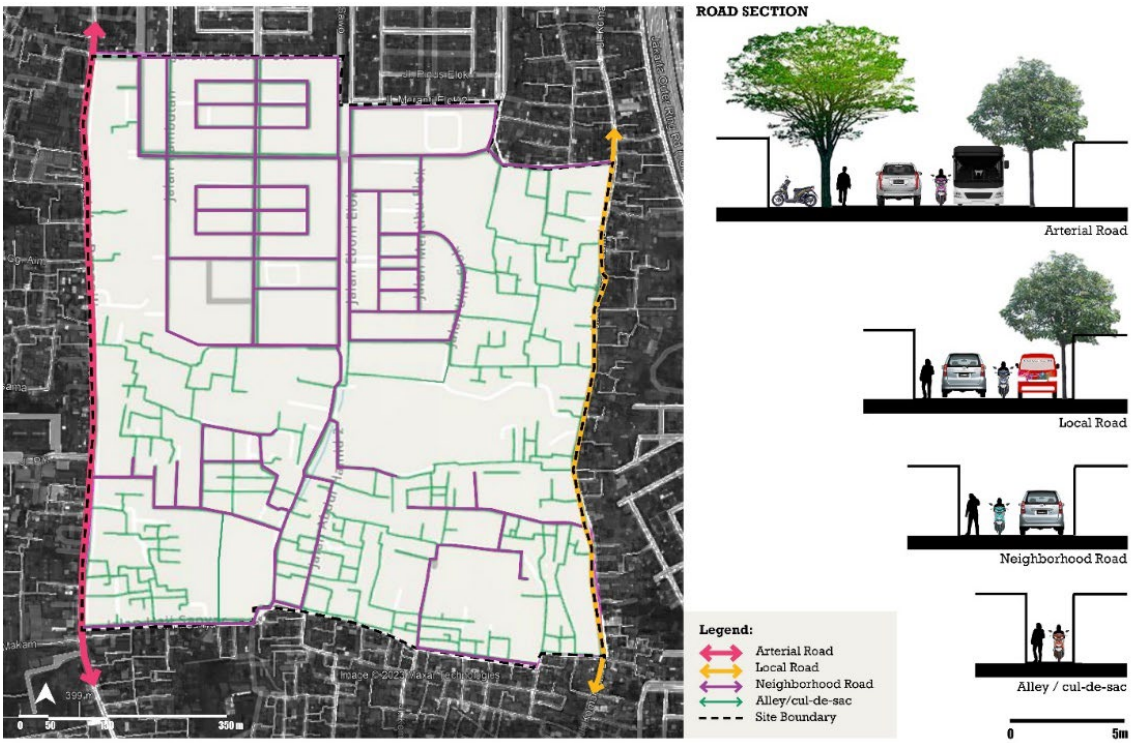

Figure 3 Permeability Based on Road Structure.
(Source: Map was adapted from Google Maps and developed based on the authors' survey)

The local road is Jalan Komarudin Lama; in the 1940s, it was a footpath route where people rode horses to travel from one village to the nearby villages. When Jalan Komarudin Lama widened to 7-meter width, the inhabitants could now travel to the nearby neighborhoods with *angkot*. *Angkot* is also typical transportation with limited routes widely used in Indonesia. Rows of stalls, restaurants, or shophouses line this road.

Neighborhood roads mainly connected the existing blocks in the case study areas. The width ranges from 6 meters as the widest to 3 meters as the smallest, depending on the location and situation. The housing complex of Komplek Pinus Elok mainly consists of non-organic dwellings laid into formal configurations, forming a regular pattern of neighborhood roads. Cars and motorcycles pass this road, but if the road width is limited, drivers must wait at certain spots to let other cars move first.

The lowest level of the road hierarchy is the alley. Dead-end alleys (*cul-de-sacs*) are other unconnected alleys in the neighborhood. The field observations revealed that most roads located at *kampung* consist of organic/informal housing types. Initially, the alley was privately owned land for public or communal use. Since its average width is less than two meters, this alley is only accessible to pedestrians and motorcycles. Motorcycles were widely used in these alleys, providing residents with a shortcut to travel from their houses to specific destinations.

The road and alley network generated continuous structure at the neighborhood scale and created good permeability. It is evident from arterial roads, neighborhood roads, and local roads that still connect to alleyways, although they have varying road widths. Permeability allows motorcycles to cross into various alternative routes, strengthening accessibility and connectivity.

4.3. Block

The blocks in the case study area vary from large to medium and small. They formed a patchwork that combined the plots bounded by roads (See Figure 4). The vertical housing development, Rusun Pulo Gebang Penggilingan, is located on large blocks of more than 6.85 ha. These blocks were previously swamps with several houses owned by locals for which the government compensated, thereby converting them into government assets. The government set boundaries along the block using concrete walls to strengthen demarcation. As a result, the boundary led to poor frontage and exclusivity.

Figure 4 Permeability Based on Block
(Source: map adapted from Google Maps and developed based on authors' survey)

Bocks in non-organic neighborhoods typically contain medium blocks ranging from 0.18 to 1.40 hectares. The block consists of houses whose boundaries are made from iron fences with openings, making the house's frontage visible from the outside. Most of the small blocks are in the *kampung*. They are divided by alleys that are mostly less than 50 meters long. As seen in other typical urban *kampungs*, tiny houses randomly build on the block with unclear boundaries. Neither concrete walls nor continuous fences mark the parcels. Most of them are owned by individuals with the alleys directly adjoin to the house's terraces.

The observations revealed that residents prefer using motorcycles to meet their daily needs. To reach other neighborhoods' blocks, the dwellers must walk more than 450 meters. Using a motorcycle become faster and easier. Small blocks provide permeability and a variety of route choices. The permeability in the study area is an example of how the mixed type of organic and non-organic development positively impacts permeability.

4.4. Streetscape

The order of roads, plots, and construction of buildings indirectly influences the urban transformation in the case study area. In addition, it affected the building's relationship to the road and its position concerning the plots. Permeability is established through the interaction of various urban elements, both organic and inorganic, resulting in a diverse urban fabric characterized by multiple intersecting patterns. Various types of roads, streets, and blocks pattern affect the quality of the streetscape as described follow (See Figure 5):

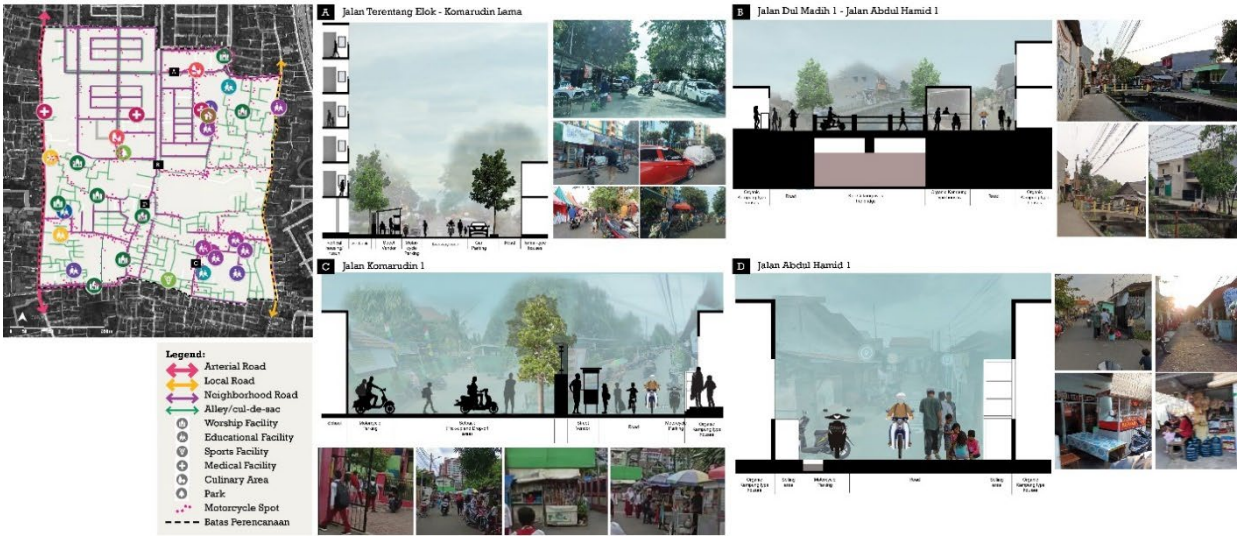

Figure 5 The Quality of Streetscapes in Permeability on a Neighborhood Scale
(Source: map adapted from Google Maps and developed based on authors' survey)

(1) Point A Jalan Terentang Elok, a six-meter-wide neighborhood road in Komplek Pinus Elok, is often busy, primarily when people conduct their everyday life, such as shopping, going to the mosque, going to school, and approaching public transportation at Jalan Komarudin Lama. The frontage of the detached-type houses mostly faced the road. However, the *rusun* or vertical housing was designed more inward-looking, so it did not create any exposure to the road. The culinary areas along the side of the road add a lively ambiance. The culinary area on Jalan Terentang Elok is a popular place among locals. They gather to shop and look for other necessities, especially in the morning when many pop-up markets appear to sell vegetables. Sometimes, the road is also used for a bazaar that supports local small entrepreneurs. Many motorcyclists park on the side of the road while they buy their necessities and enliven the road. This straight road makes motorcycles' movement easy enough for high speed. On the other hand, pedestrians often resort to walking on the road, posing significant safety risks, particularly when they are with their children. The streets exemplify typical thoroughfares in developing urban areas within Indonesian cities, where motor vehicles dominate, leaving pedestrians at a disadvantage (Ellisa & Ramadityo, 2019).

(2) Point B, Jalan Haji Dul Madih 1 – Jalan Abdul Hamid-1 stretch along the Kali Cakung River. Lynch (1961) perceives the river as an edge as the legibility element connected to movement and building forms that follow the water line. This neighborhood road, which lies in the organic *kampung* neighborhood, is frequently used by motorcycles as a shortcut to both Komarudin Lama (to the east) and Penggilingan Raya (to the west)—the access made possible by a bridge over the river that connects them. The locals also use the road to purchase daily necessities in the *warung* located on the river house terrace. The house's

frontage mainly faces the river, making it more attractive to the public. These findings relate to Lynch's statement (1961) that emphasizes the favorable visual impact of water, implying that many people are attracted to view the riverbank, and thus suggests a road that follows the line of the water, with a continuous line of buildings on the waterfront. On the other side, the traffic on this road became increasingly crowded after the Rusun Pulo Gebang Penggilingan's construction. The crossing is not designed well; meanwhile, most *rusun* residents belong to low incomes groups who rely on private motorcycles or *ojek* for daily commuting due to the lack of public transportation.

(3) Point C, Jalan Komarudin 1, is a neighborhood road between organic neighborhoods dominated by tiny houses of one or two floors. This road is 3 meters wide and is a shortcut to the nearby road, especially for accessing numerous schools and educational facilities. Most of the motorcycle is used by a parent who transport their children to school. They parked their motorcycle near the school gate, *warung*, and street vendors. The road tends to become congested during the hours before and after school. The pedestrians navigate through the streets, often brushing against street vendors as they try to avoid motorcycles. There is no designated school zone, motorcycle dropping-off areas, parking facilities, and clear signs to guarantee that pedestrians, cyclists, and motorcycles harmoniously side by side.

(4) Point D is Jalan Abdul Hamid 1, a small neighborhood road that becomes the main route for motorcycles. This road is 3 meters wide. On both sides of the road is an organic neighborhood with 1-2 floors. While it functions as vehicle access, this alley is also a space for the locals to meet others, intentionally or unintentionally, and even becomes a playing space for children. The resident also contributes to the liveliness of the street by offering food and beverages for sale. The motorcycle slows down when there is a curvy or meandering road and speed bump. However, there needs to be more distinct materials and colors implemented to enhance pedestrian safety or designate parking areas. The local people also put up a sign for motorcycles to decrease speed because many children play on the road. However, there is no specific speed restriction regulation in the neighborhood.

The permeability and motorcycle mobility trajectory implicates the evolving relationship between these factors. From a historical perspective, motorcycles have been a part of transportation for years, especially for commuters. Only now, the number of motorcycles has grown fast; therefore, cities need specific infrastructure or design elements to accommodate motorcycles, especially on the neighborhood scale. The permeability on a neighborhood scale relates to the negotiation space between motorcycles mobility and residents, including street vendors. The stakeholders must recognize safety and infrastructure improvements for motorcycle riders, pedestrians, and cyclists. It led to the implementation of dedicated traffic calming measures, safe crossing, speed restriction, and improved road signage or markings to enhance the overall infrastructure for motorcycles and pedestrians.

Addressing parking for motorcycles is another significant aspect that should be considered for the neighborhood. As the number of motorcycles continues to rise, it becomes crucial to develop dedicated motorcycle parking areas, such as constructing multi-level parking structures for high-density areas and integrating motorcycles with public transportation hubs. In addition, motorcycles also lack formal regulations regarding the transportation of passengers as opposed to goods. There is potential to incorporate motorcycles into integrated mobility systems with further improvements. Stakeholders had to start considering the presence of motorcycles and their unique requirements. By investigating the benefits and problems of motorcycle mobility, we can create safe, sustainable, and inclusive urban environments.

5. CONCLUSION

The rapid urbanization of Southeast Asian cities, particularly Jakarta, led to diverse urban forms, setting them apart from the largely homogeneous cities in Western countries. The proliferation of motorcycles and the expansion of urban areas on the outskirts of cities have significantly transformed the layout of the outskirt of Jakarta. The case study highlights the importance of permeability, which refers to the ease of mobility within a city, particularly using motorcycles. Motorcycles play a crucial role in enhancing the permeability of Jakarta and similar regional cities. Traveling in large blocks was previously challenging due to the long distances and narrow streets that cars could not pass through, and pedestrians would take too long to cover. However, motorcycles have made it feasible to navigate these areas, making them more accessible and improving mobility. Motorcyclists can use alleys as shortcuts, which makes traveling even faster.

The concept of permeability at a neighborhood level aligns with Lynch's idea of maximizing accessibility and connectivity, albeit through different modes of mobility and in different contexts. Designers are responsible for creating solutions that can accommodate the growing demand for mobility across various modes. With digitalization and emerging transportation options, the way forward is to develop a seamless mobility system that integrates public, shared, and private transportation, as noted by Charlesworth (2005). In today's era, there is a need to develop a mobility system that can accommodate the changing modes of transportation and urban environments. The responsibility of designers is to create a comfortable and convenient mobility system without any compulsion to move in specific modes.

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CONSTRUCTION AND PRELIMINARY APPLICATION OF THE CARBON-BASED SPATIAL GOVERNANCE PERFORMANCE EVALUATION SYSTEM: TAKING ZHEJIANG PROVINCE AS AN EXAMPLE

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ABSTRACT

Carbon is generated through human socio-economic activities, with territorial space serving as the medium for these activities. Variations in spatial governance result in differences in the scale, intensity, and efficiency of social and economic activities, energy and resource consumption, and carbon emissions across diverse functional spaces. Consequently, spatial governance performance should be evaluated using carbon-related indicators. This study initially established a theoretical model for assessing spatial governance performance based on carbon and an evaluation method encompassing three dimensions or indices, "level-progress-gap." Zhejiang Province and its 11 prefecture-level cities were selected as the research area for preliminary application to explore the spatial governance performance and existing challenges under differentiated management and control. Finally, policy recommendations were proposed to enhance spatial governance performance and integrate low-carbon development.

Keywords: spatial governance performance; level index; progress index; gap index

1. INTRODUCTION

In recent years, urbanization has not only led to the growth of urban populations but also contributed to the expansion of construction land and the high concentration of socio-economic activities in urban areas, subsequently altering the spatial structure of the territory. Carbon, a byproduct of human socio-economic activities and biological metabolism, has significantly increased due to extensive development, leading to heightened carbon emissions, energy consumption, and pollutant emissions, exacerbating the greenhouse effect. In December 2020, China's Central Economic Work Conference outlined the ambitious objective of achieving "carbon peaking by 2030 and carbon neutrality by 2060" (after this, referred to as the "dual carbon targets") as a crucial task, marking the beginning of the implementation of China's carbon peaking and carbon neutrality policies.

Since the 20th century, the term "governance" has gained widespread use in managing public affairs. As research deepens, governance's regional and spatial scale becomes increasingly significant (Kong et al., 2023). Territorial space, the physical medium of human socio-economic activities, is a product of the interaction between spatial elements and human activities.

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Spatial governance aims to reconstruct and reshape imbalanced and disordered spaces' protection and utilization mechanisms to promote a balanced spatial layout, precise element allocation, integrated ecological protection, and efficient resource utilization (Zhu & Dai, 2023).

In essence, spatial governance controls and guides human socio-economic activities to achieve or enhance regional sustainable development and ensure regional ecological security. It is essential to accomplish the "dual carbon targets." In December 2016, the Central Committee of the Communist Party of China and the General Office of the State Council of the People's Republic of China issued the Pilot Program of Provincial Spatial Planning, which proposed comprehensively understanding and analyzing territorial space background conditions based on central functional zone planning, and delineating urban, agricultural and ecological spaces as well as ecological protection red lines, permanent basic farmland, and urban development boundaries, which is referred to as "three-zones and three-lines" (Liu & Ma, 2019). China has established a spatial governance model of differentiated management and control for urban, agricultural, and ecological spaces, prompting numerous studies on spatial governance performance. While Chinese academia generally considers performance as a "behavior and result" encompassing work behavior, mode, outcome, and objective influence within a certain period (Y. Huang, 2021), direct definitions of spatial governance performance are scarce. This paper posits that spatial governance performance refers to evaluating the government's actual spatial governance impact and represents a quantitative measurement of the phase and sustainability of the government's spatial governance behavior.

Regarding the measurement of spatial governance performance, current research primarily focuses on constructing evaluation systems based on the economic scale, technological progress, environmental regulation, industrial structure, energy efficiency, government financial expenditure, and trade openness. Commonly employed evaluation methods include entropy, a comprehensive index, and data envelopment analysis (Dong et al., 2016; L. Huang & Wu, 2018; E. Wang & Wu, 2011; Zhang et al., 2014). However, these approaches exhibit several limitations: First, some studies feature evaluation systems with an excessive number of indicators, causing the advantages and disadvantages of factors influencing governance performance to offset one another. Consequently, the evaluation results converge, making it difficult to discern regional differences. Second, there needs to be consistency in indicator screening, weight setting, and evaluation methods. Specifically, the selection of certain indicators is determined by the availability of basic data in the assessed regions, reducing comparability and objectivity between regions and affecting the indicator system's applicability. Third, performance evaluations are predominantly conducted in administrative regions, examining short-term and static regional characteristics, with limited research into multi-stage and dynamic features from the perspective of "urban, agricultural, and ecological space." To address these limitations, this paper proposes constructing a carbon-based spatial governance performance evaluation system based on the effectiveness of urban, agricultural, and ecological spatial governance. By integrating static and dynamic viewpoints, the research aims to explore effective methods for reducing carbon emissions, enhancing spatial governance performance, and further promoting the modernization of governance capacity and systems. A preliminary application and analysis are performed using Zhejiang Province and its 11 prefecture-level cities as a case study.

2. THEORETICAL MODEL AND METHODS

2.1 Construction of the Theoretical Model for Carbon-Based Spatial Governance Performance Evaluation

The "dual carbon targets" should be implemented across various levels of administration, from the national to local levels, and within different functional zones like urban, agricultural, and

ecological spaces. Employing differentiated management and control methods for territorial space facilitates accurate positioning of the scope and function of urban, agricultural, and ecological spaces, rational allocation of resources, and limitation of excessive construction land expansion while upholding the bottom line for cultivated land and ecological land. By emphasizing economic efficiency in urban spaces, agricultural development and food security in agricultural spaces, and ecological protection in ecological spaces, a high-quality development pattern can be realized, reversing the extensive model of territorial space development.

Carbon is the product of human socio-economic activities, while territorial space is the carrier for these activities. Distinct spatial governance approaches result in variations in the scale, intensity, and efficiency of socio-economic activities, energy and resource consumption, and carbon emissions across countries, regions, administrative levels, and functional zones. No universally accepted, applicable, or effective indicator system exists for evaluating spatial governance performance. As human socio-economic activities evolve and space under spatial governance, carbon, an indicator that permeates all aspects and stages of the social and economic environment, may appear singular but encompasses many factors. Carbon can provide a comprehensive and holistic assessment of socio-economic activities and spatial governance efficiency in different administrative regions or distinct functional zones within the same region.

Consequently, it is appropriate to use carbon-related indicators to represent socio-economic activity attributes (such as scale, intensity, and efficiency) and employ them to guide and constrain spatial protection and regional development behaviors. Wherein total carbon emissions (referred to as net carbon emissions hereafter) represent the difference between carbon emissions and carbon sinks generated by a region's overall production and living activities, measuring the baseline size of carbon emissions and emission reduction potential. Carbon emissions per unit GDP, the ratio of total carbon emissions to regional GDP, reflects the quality of regional economic development. In contrast to the economic development benefits indicated by per capita GDP, carbon emissions per unit GDP emphasize the green and high-end levels of regional industries. Carbon emissions per capita, the ratio of total carbon emissions to regional population, measures human development rights and equity. Carbon emissions per unit area, the ratio of total carbon emissions to regional land area, reflects the ecological and environmental pressure of total regional carbon emissions.

Ultimately, existing research concentrates on spatial governance's short-term and static characteristics. This paper aims to develop a spatial governance performance evaluation method that thoroughly reflects its actions, processes, and levels by comparing the overall regional level, historical context, and established benchmark. This method integrates a three-way feature analysis encompassing "timeliness, spatiality, and complexity." Through the perspectives of level, progress, and gap (Bao et al., 2017), a spatial governance performance evaluation method is established (see Figure 1).

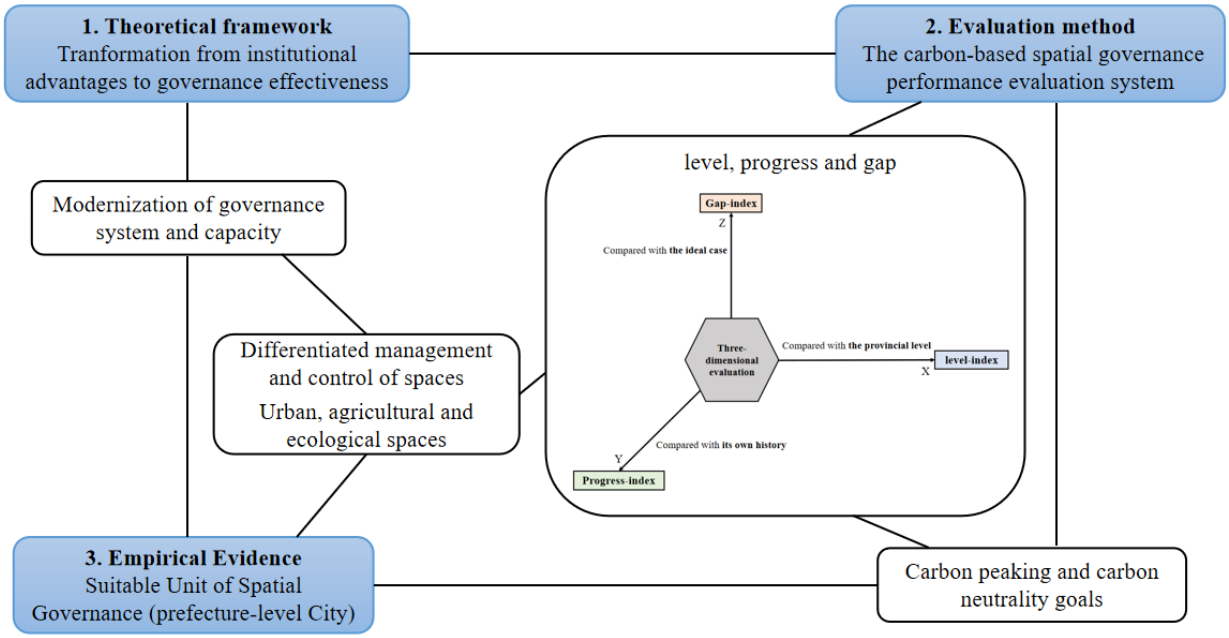

Figure 1 Theoretical Model and Method for Carbon-based Spatial Governance Performance Evaluation

2.2 Indicator System

This paper employs total carbon emissions per unit of GDP, carbon emissions per capita, and carbon emissions per unit area as indicators to assess spatial governance and low-carbon development from various perspectives, all of which are inverse indicators. Since each evaluation indicator affects spatial governance performance to varying degrees, each indicator should be assigned a suitable weight. This paper utilizes the relatively objective coefficient of variation method, which determines the weight by normalizing the indicator data's dispersion. In the evaluation indicator system, an indicator with greater differences in values is more challenging to achieve and can better reflect the evaluated region's gap. The specific calculation method (L. Shi & Sun, 2018) is as follows:

$$W_i = \frac{V_i}{\sum_{i=1}^{n} V_i}$$

$$V_i = \frac{S_i}{\bar{X}}$$

$$S_i = \sqrt{\frac{1}{N}\sum_{j=1}^{N}(X_j - \bar{X})^2}$$

Where W_i is the weight of the i-th indicator, V_i is the standard deviation of the i-th indicator divided by its mean value, $\bar{X}$ is the mean value of the i-th indicator sample, S_i is the standard deviation of the i-th indicator sample, n is the number of sub-regions to be evaluated, $N = 2n$.

2.3 Evaluation Method

To assess the spatial governance performance of an administrative region or functional zone comprehensively and effectively, it is crucial to integrate various perspectives, including comparisons with the region's overall level, historical comparisons, and comparisons with optimal conditions.

2.3.1. Level Index

The level index represents the degree to which each indicator value of the evaluated sub-region compares with the overall level of the region. Assuming there are n evaluation objects, m sub-indicators, and the value of the j-th $(j = 1,\ldots,)$ sub-indicator of the i-th $(i = 1,\ldots,n)$ evaluation object is P_{ij} (same below), n is the number of sub-regions to be evaluated. The larger the indicator value, the higher the evaluation value. The threshold method is used to perform non-dimensional processing on each indicator value. The calculation process is as follows:

$$P_{ij} = \begin{cases} \dfrac{p_{total} - p_{ij}}{\max\limits_{1 \ll i \ll n} p_{ij} - \min\limits_{1 \ll i \ll n} {}_{ij}} \times 45 + 55 & \text{(reverse indicators)} \\ \dfrac{p_{ij} - p_{total}}{\max\limits_{1 \ll i \ll n} p_{ij} - \min\limits_{1 \ll i \ll n} p_{ij}} \times 45 + 55 & \text{(positive indicators)} \end{cases}$$

Where P_{ij} is the level evaluation value of the j-th indicator of the i-th evaluation object, p_{total} is the index value of the overall level of the region in the current year, p_{ij} is the index value of each sub-region in the current year. Taking the overall level as 55 points, a score higher than 55 points indicates a higher level than the overall level, while a score lower than 55 points indicates a lower level than the overall level.

The weighted average of each sub-indicator is the spatial governance performance level index of the i-th evaluation object, as shown in the following formula:

$$S_{i\ level} = \sum_{j=1}^{m} W_j\, P_{ij}$$

Where $S_{i\ level}$ represents the spatial governance performance level index of the i-th evaluation object, and W_j describes the weight of the j-th indicator.

2.3.2. Progress Index

The progress index is the degree of progress of each indicator compared to the historical level of the region, reflecting the level of spatial governance and low-carbon development progress in the evaluation area. The calculation process is shown in the following formula:

$$p_{ij} = \begin{cases} \dfrac{p_{ij}{}' - p_{ij}{}''}{p_i{}''} & \text{(reverse indicators)} \\ \dfrac{p_{ij}{}'' - p_{ij}{}'}{p_{ij}{}''} & \text{(positive indicators)} \end{cases}$$

Where p_{ij} is the indicator progress rate of the j-th indicator of evaluation object i, $p_{ij}{}'$ is the status indicator value, and $p_{ij}{}''$ is the early indicator value.

Using the threshold method, the progress rate is normalized, and the calculation process is shown in the following formula:

$$P_{ij} = \frac{p_{ij} - \min\limits_{1 \ll i \ll n} p_{ij}}{\max\limits_{1 \ll i \ll n} p_{ij} - \min\limits_{1 \ll i \ll n} p_{ij}} \times 45 + 55$$

Where P_{ij} is the progress evaluation value of the j-th indicator of evaluation object i.

The weighted average of each sub-indicator is used to obtain the spatial governance performance progress index of evaluation object i, as shown in the following formula:

$$S_{i\ progress} = \sum_{j=1}^{m} W_j \ P_{ij}$$

Where $S_{i\ progress}$ represents the spatial governance performance progress index of evaluation object i, and W_j represents the weight of the j-th indicator.

2.3.3. Gap Index

The gap index refers to the difference between the index values of each sub-region and the optimal level in the overall region, representing the gap between each sub-region and the ideal case. The calculation process is shown in the following equation:

$$P_{ij} = \begin{cases} \dfrac{p_{ideal} - p_{ij}}{\max\limits_{1 \ll i \ll n} p_{ij} - \min\limits_{1 \ll i \ll n} p_{ij}} \times 45 + 55 & \text{(reverse indicators)} \\ \dfrac{p_{ij} - p_{ideal}}{\max\limits_{1 \ll i \ll n} p_{ij} - \min\limits_{1 \ll i \ll n} p_{ij}} \times 45 + 55 & \text{(positive indicators)} \end{cases}$$

Where P_{ij} is the gap evaluation value of the j-th indicator of evaluation object i, p_{ideal} is the outstanding case indicator value constructed, and p_{ij} is the current indicator value of each sub-region. Taking the ideal case as 55 points, if each sub-region is lower than 55 points, the smaller the difference between the sub-region and the ideal case (55 points), the smaller the gap.

The weighted average of each sub-indicator is used to obtain the spatial governance performance gap index of the evaluation object i, as shown in the following formula:

$$S_{i\ gap} = \sum_{j=1}^{m} W_j \ P_{ij}$$

Where the $S_{i\ gap}$ represents the spatial governance performance gap index of the evaluation object i, and W_j represents the weight of the j-th indicator.

2.3.4. Comprehensive Index

The comprehensive index is calculated by taking the arithmetic mean of the level index and the gap index as the base, converting the progress index into a correction coefficient, and multiplying the base by the correction coefficient. The formula is as follows:

$$I_{comprehensive} = \frac{1}{2}(I_{level} + I_{gap}) \times (I_{progress}/100)$$

3. RESEARCH AREA OVERVIEW

3.1 Area Overview and Data Sources

Zhejiang Province, situated on the southeastern coast of China within the southern wing of the Yangtze River Delta, encompasses 11 prefecture-level cities (see Figure 2). The terrain descends in a step-like manner from southwest to northeast, featuring mountains and hills in the southwest, hills, and basins in the central region, and hills and plains in the northeast.

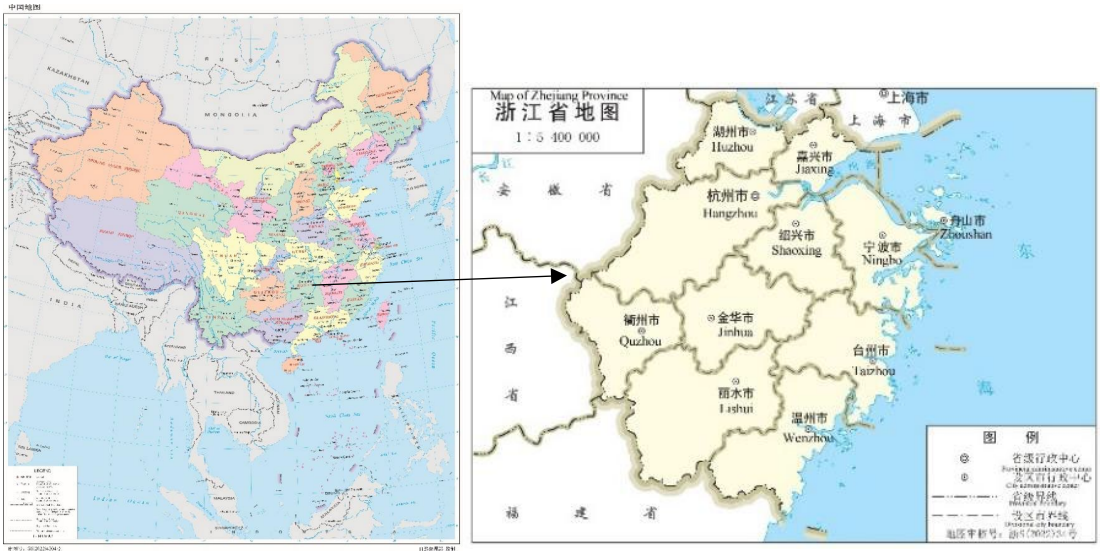

Figure 2 Administrative Division Map of Zhejiang Province

As illustrated in Figures 3 and 4, Zhejiang Province has experienced a continuous increase in total energy consumption in recent years, with coal, oil, and natural gas constituting a significant portion. Although the proportion of coal consumption has declined annually, the overall carbon emissions remain high, and substantial pressure persists in controlling total energy consumption and adjusting the consumption structure.

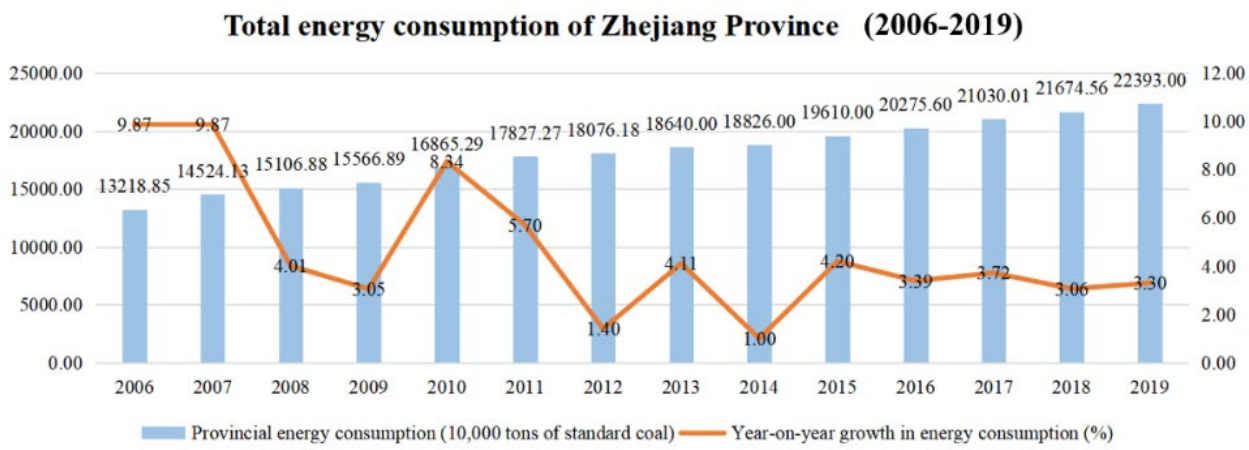

Figure 3 Changes in Total Energy Consumption in Zhejiang Province from 2006 to 2019

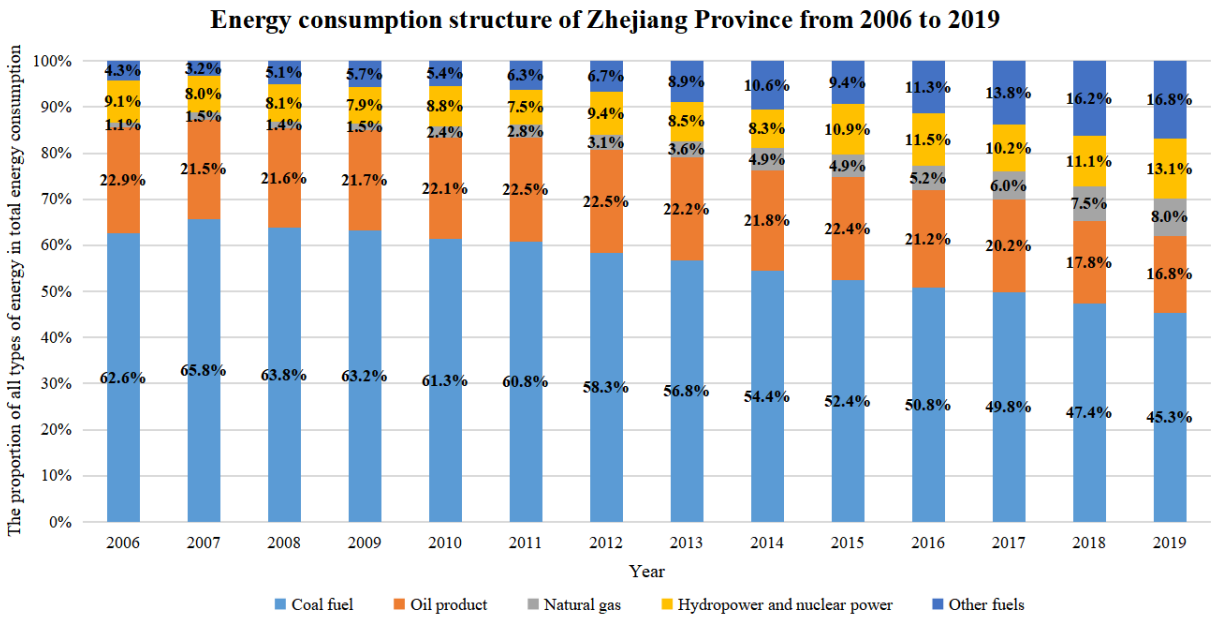

Figure 4 Changes in the Proportion of Energy Consumption Structure in Zhejiang Province from 2006 to 2019

The raw geographic data used in this paper is derived from *the Resource and Environmental Science Data Center of the Chinese Academy of Sciences (http://www.resdc.cn)*. Land use data is sourced from *the Land Survey Results Application Sharing Service Platform (https://tddc.mnr.gov.cn)* and *the Major Data Bulletin of the Third National Land Survey*. Carbon emissions data is obtained from *the statistical yearbooks of Zhejiang Province and various prefecture-level cities in 2016 and 2020*, *the General Calculation Methods for Comprehensive Energy Consumption (GBT2589-2020)*, and *the Benchmark Emission Factors of Regional Power Grids in China in 2015 and 2019*, and related research results. Planning data is collected from *the 13th and 14th national economic and social development five-year plans of Zhejiang Province and various prefecture-level cities*, *land use plannings*, *special plannings*, and relevant policies and regulatory documents.

3.2 Construction of Spatial Classification System

To align with the implementation of spatial planning and the "three-zones and three-lines" mode and considering the specific circumstances of Zhejiang Province and land use classification standards, this paper categorizes land space into three types: urban space, agricultural space, and ecological space, as displayed in Table 1.

Urban space primarily serves urban residents' production, living, and economic development, with construction land as the main carbon source. Agricultural space is predominantly used for rural residents living and agricultural production, encompassing cultivated land, orchards and other agricultural land. Carbon sources and sinks coexist in this space, ultimately functioning as carbon sources. Ecological space chiefly provides ecological products and services, incorporating various ecological elements such as forest land, grassland, rivers, and beaches (Y. Wang et al., 2018), primarily acting as carbon sinks.

Table 1 Spatial Classification System of Zhejiang Province

Spatial Types	Land Use Types	
Urban Space	Construction land	Carbon Source
Agricultural Space	Cultivated land	Carbon Source
	Orchard	Carbon Sink
	Other agricultural land	Carbon Source
Ecological Space	Forest land	Carbon Sink
	Grassland	Carbon Sink
	Water area and water conservancy facilities	Carbon Sink
	Unused land	Carbon Sink

As illustrated in Figure 5 and Table 2, three types of space in Zhejiang Province exhibit a fragmented distribution, characterized by small urban space areas and extensive ecological space areas. From 2015 to 2019, the areas of urban and ecological spaces expanded while the agricultural space area contracted.

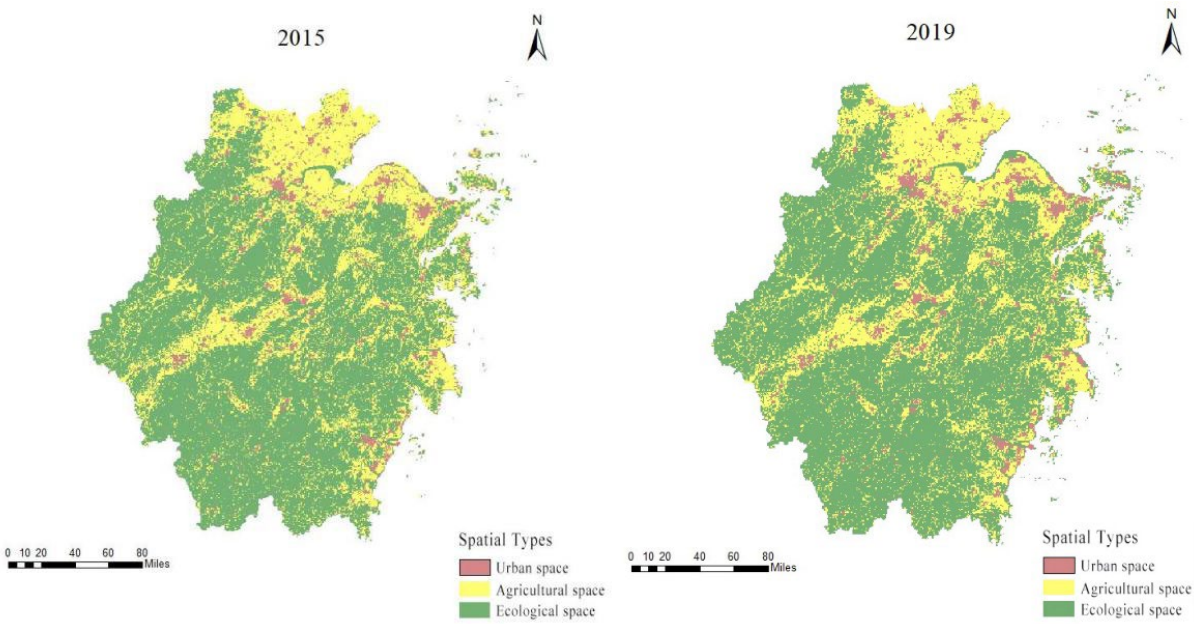

Figure 5 Distribution of Urban, Agricultural and Ecological Space in Zhejiang Province in 2015 and 2019

Table 2 Land Area of Urban, Agricultural and Ecological Spaces in Zhejiang Province in 2015 and 2019 (Unit: 10,000 km^2)

City	Urban Space				Agricultural Space				Ecological Space			
	2015	%	2019	%	2015	%	2019	%	2015	%	2019	%
Zhejiang	58.67	5.56	70.61	6.68	346.34	32.81	293.22	27.75	650.45	61.63	692.86	65.57
Hangzhou	8.71	5.17	11.89	7.06	43.77	25.98	34.07	20.22	116.02	68.85	122.54	72.72
Huzhou	3.75	6.44	4.40	7.56	28.47	48.91	26.39	45.34	25.99	44.65	27.41	47.10
Jiaxing	5.33	12.6	7.63	18.01	30.61	72.49	27.23	64.30	6.28	14.88	7.49	17.70
Jinhua	6.57	6.00	7.39	6.76	39.24	35.86	32.40	29.61	63.61	58.14	69.62	63.63
Lishui	2.28	1.32	2.67	1.54	29.37	17.00	24.46	14.16	141.11	81.68	145.62	84.30
Ningbo	10.95	11.26	1.18	12.00	36.03	37.04	32.62	33.23	50.30	51.71	53.76	54.77
Quzhou	2.93	3.31	3.17	3.58	28.09	31.76	24.35	27.53	57.43	64.94	60.93	68.89
Shaoxing	5.57	6.72	6.39	7.72	35.40	42.76	30.64	37.01	41.82	50.52	45.76	55.27
Taizhou	5.42	5.40	6.61	6.58	33.73	33.58	29.77	29.62	61.30	61.03	64.11	63.80
Wenzhou	5.38	4.45	6.63	5.47	37.06	30.67	27.35	22.58	78.39	64.88	87.13	71.95
Zhoushan	1.80	12.36	2.06	13.24	4.55	31.28	3.93	25.31	8.20	56.36	9.55	61.45

3.3 Estimation of Carbon Source and Sink

3.3.1. Calculation of Major Energy Carbon Emissions

The carbon emissions on construction land mainly come from coal, oil, natural gas, and electricity. According to the energy consumption structure of various cities in Zhejiang Province, coal includes raw coal and coke, and oil includes gasoline, diesel, and fuel oil. The specific calculation formula [10] is as follows:

$$C = \sum_i C_i = \sum_i P_i \times R_i \times \frac{12}{44}$$

Where P_i is the total consumption of the i-th energy source, R_i is the carbon emission factor of the i-th energy source (Table 3) or the benchmark emission factor of the regional power grid (Table 4). i=1,…,7.

Table 3 Coal, Oil and Natural Gas Carbon Emission Factors

Energy type		Carbon emission factor	Unit
Coal	Raw coal	1.90	tCO_2/t fuel
	Coke	2.86	tCO_2/t fuel
Oil	Gasoline	2.93	tCO_2/t fuel
	Diesel	3.10	tCO_2/t fuel
	Fuel oil	3.17	tCO_2/t fuel
Natural gas		19.76	$tCO_2/10^4$ m^3 fuel

Table 4 Benchmark emission factor of the regional power grid in East China, China

Year	Emission factor	Unit
2015	0.8112	tCO_2/1000kWh
2019	0.7921	

3.3.2. Calculation of Carbon Emissions of Major Land Use Types

In addition to construction land, carbon emissions are also generated from land use types such as cropland, orchards, forests, grassland, water bodies, and unused land. Among them, cropland is a carbon source, while orchards, forests, grassland, water bodies, and unused land are carbon sinks. The specific calculation formula (Li et al., 2022) is as follows:

$$C = \sum_j C_j = \sum_j A_j \times \alpha_j$$

Where A_j is the land area of the j-th land use type, and α_j is the carbon emission coefficient of the j-th land use type (Table 5). j=1,…,6.

Table 5 Reference table of carbon emission coefficients of land use types

Land Use Type	Cropland	Orchard	Forest Land	Grassland	Water Bodies and Water Conservancy Facilities	Unused Land
Parameter Value t /（hm^2·a）	0.4220	-0.7300	-0.6125	-0.0210	-0.0248	-0.0005

Source: Duan et al., 2008; Fang et al., 2007; Lai, 2010; Li et al., 2022; H. Shi et al., 2012; H. Sun et al., 2015; X. Sun, 2012; Yuan & Tang, 2019; Zhang et al., 2012; Zhao et al., 2013

3.3.3. Net Carbon Emissions in Three Spatial Types

Based on the calculations, carbon emissions from urban spaces primarily stem from coal, oil, natural gas, industrial electricity consumption, and urban residential electricity consumption. The carbon sink accounts for approximately 0.008% of the carbon emissions, which can be disregarded for the time being. Carbon emissions from agricultural spaces are concentrated in rural residents' electricity consumption and cultivated land, while the carbon sink is primarily found in orchards. Carbon sinks from ecological spaces are mainly located in forests, grassland, water, and unused land. Consequently, the net carbon emissions of urban, agricultural, and ecological spaces in Zhejiang Province in 2015 and 2019 can be calculated (see Table 6). From 2015 to 2019, carbon emissions increased in urban and agricultural spaces, while carbon sinks in ecological spaces rose slightly. However, the base remained small, resulting in overall growth in net carbon emissions.

Table 6 Net Carbon Emissions in Three Spatial Types in Zhejiang Province in 2015 and 2019 (Unit: ktC)

City	Urban Space（10^4）		Agricultural Space（10^4）		Ecological Space	
	2015	2019	2015	2019	2015	2019
Zhejiang	13567.50	15617.51	456.51	626.41	-3494.34	-3762.12
Hangzhou	1901.39	1763.85	73.90	105.03	-632.15	-678.87
Huzhou	832.41	1026.56	21.53	32.78	-134.43	-143.71
Jiaxing	1631.16	1957.86	28.62	44.06	-3.92	-11.86
Jinhua	894.23	1042.73	47.26	62.11	-363.82	-398.08
Lishui	175.34	232.48	13.40	18.89	-830.21	-849.43
Ningbo	3105.93	3482.58	69.92	99.48	-232.24	-256.87
Quzhou	698.70	804.36	16.31	23.95	-329.43	-348.76
Shaoxing	842.06	1473.79	35.63	48.04	-219.12	-242.42
Taizhou	979.82	1312.45	64.90	54.80	-312.23	-334.26
Wenzhou	1269.14	1359.47	75.13	127.19	-403.81	-457.94
Zhoushan	461.33	604.98	9.90	10.06	-32.89	-39.91

4. RESULTS

4.1. Overall Assessment of Carbon Emission Performance in Each Prefecture-level City

In this paper, total carbon emissions per unit of GDP, carbon emissions per capita, and carbon emissions per unit area are selected as indicators to investigate spatial governance and low-carbon development in Zhejiang Province's prefecture-level cities from the perspective of the overall administrative region. The 2019 overall spatial governance performance level index (see Table 7), progress index (see Table 8), gap index (see Table 9), and comprehensive index (see Table 10) of prefecture-level cities in Zhejiang Province can be calculated. Since the level index compares data from prefecture-level cities with the provincial level, and the gap index compares data with the "ideal case" (the optimal provincial level), both indices essentially involve comparisons and calculations within the province. Although there are differences in data magnitude, the meanings conveyed are consistent with the results presented. Consequently, the level index and gap index can be combined for analysis and comparison.

According to total carbon emissions, Hangzhou, Jiaxing, and Ningbo are high-carbon emission cities due to their large scale of production and living. At the same time Lishui, Zhoushan, and Quzhou are low-carbon emission cities. Carbon emissions are closely related to industrial structure, population, and regional area, revealing significant differences in economic development modes and environmental quality among cities when considering each city's GDP, population, and land area.

Among the cities with high carbon emissions, Hangzhou has relatively low carbon emissions per unit GDP, carbon emissions per capita, and carbon emissions per unit area, particularly the lowest carbon emissions per unit GDP in the province. This is attributed to Hangzhou's leading development pattern of the digital economy. With the significant enhancement of the innovation

source function of the Science and Technology Innovation Corridor in the west of the city, its economic development has gradually decoupled from carbon emissions. Pillar industries like the Internet have achieved high-quality development with low consumption, pollution, and efficiency. Simultaneously, the construction of "Beautiful Hangzhou" has made new achievements, becoming the first national ecological city among provincial capitals.

Table 7 Spatial Governance Performance Level Index Ranking of Prefecture-level Cities in Zhejiang Province in 2019

Overall			**Carbon Emissions**			**Carbon Emissions per Unit of GDP**			**Carbon Emissions Per Capita**			**Carbon Emissions per Unit Area**		
City	Score	Ranking	City	Score	Ranking	City	Score	Ranking	City	Score	Ranking	City	Score	Ranking
Lishui	72.30	1	Lishui	71.56	1	Hangzhou	74.58	1	Lishui	75.02	1	Lishui	73.02	1
Jinhua	62.89	2	Zhoushan	66.64	2	Lishui	69.17	2	Wenzhou	69.93	2	Quzhou	65.25	2
Hangzhou	62.36	3	Quzhou	63.76	3	Wenzhou	63.07	3	Hangzhou	67.67	3	Jinhua	64.53	3
Wenzhou	61.84	4	Huzhou	60.64	4	Jinhua	61.16	4	Jinhua	65.91	4	Hangzhou	63.55	4
Taizhou	59.68	5	Jinhua	60.02	5	Shaoxing	58.83	5	Taizhou	63.06	5	Wenzhou	62.39	5
Shaoxing	55.86	6	Taizhou	56.48	6	Taizhou	58.49	6	Shaoxing	54.42	6	Taizhou	61.09	6
Huzhou	55.21	7	Wenzhou	54.87	7	Ningbo	54.87	7	Huzhou	49.45	7	Huzhou	56.57	7
Quzhou	54.65	8	Shaoxing	54.39	8	Huzhou	50.38	8	Quzhou	46.45	8	Shaoxing	56.39	8
Zhoushan	43.94	9	Hangzhou	49.70	9	Jiaxing	46.65	9	Jiaxing	41.66	9	Ningbo	38.61	9
Jiaxing	39.84	10	Jiaxing	47.90	10	Zhoushan	38.24	10	Ningbo	41.41	10	Zhoushan	35.59	10
Ningbo	38.61	11	Ningbo	26.56	11	Quzhou	29.58	11	Zhoushan	30.02	11	Jiaxing	28.02	11

Table 8 Spatial Governance Performance Gap Index Ranking of Prefecture-level Cities in Zhejiang Province in 2019

Overall			**Carbon Emissions**			**Carbon Emissions per Unit of GDP**			**Carbon Emissions Per Capita**			**Carbon Emissions per Unit Area**		
City	Score	Ranking	City	Score	Ranking	City	Score	Ranking	City	Score	Ranking	City	Score	Ranking
Lishui	54.03	1	Lishui	55.00	1	Hangzhou	55.00	1	Lishui	55.00	1	Lishui	55.00	1
Jinhua	44.62	2	Zhoushan	50.09	2	Lishui	49.60	2	Wenzhou	49.91	2	Quzhou	47.23	2
Hangzhou	44.08	3	Quzhou	47.20	3	Wenzhou	43.50	3	Hangzhou	47.65	3	Jinhua	46.51	3
Wenzhou	43.56	4	Huzhou	44.08	4	Jinhua	41.58	4	Jinhua	45.89	4	Hangzhou	45.54	4
Taizhou	41.40	5	Jinhua	43.47	5	Shaoxing	39.25	5	Taizhou	43.05	5	Wenzhou	44.37	5
Shaoxing	37.59	6	Taizhou	39.92	6	Taizhou	38.91	6	Shaoxing	34.41	6	Taizhou	43.07	6
Huzhou	36.94	7	Wenzhou	38.31	7	Ningbo	35.29	7	Huzhou	29.43	7	Huzhou	38.55	7
Quzhou	36.38	8	Shaoxing	37.83	8	Huzhou	30.80	8	Quzhou	26.44	8	Shaoxing	38.38	8
Zhoushan	25.66	9	Hangzhou	33.15	9	Jiaxing	27.08	9	Jiaxing	21.64	9	Ningbo	20.59	9
Jiaxing	21.56	10	Jiaxing	31.35	10	Zhoushan	18.67	10	Ningbo	21.39	10	Zhoushan	17.57	10
Ningbo	20.34	11	Ningbo	10.00	11	Quzhou	10.00	11	Zhoushan	10.00	11	Jiaxing	10.00	11

In contrast, Ningbo and Jiaxing have higher carbon emissions per unit GDP, carbon emissions per capita, and carbon emissions per unit area. Although the GDP of both cities is at the forefront of the province, Ningbo's development of a knowledge-intensive service industry and high-tech manufacturing industry is insufficient. Jiaxing has a low industrial level, with a weak foundation for the integrated development of advanced manufacturing and modern service industries. Furthermore, resource scarcity and low utilization efficiency tighten population, resources, and environmental constraints.

Among the cities with low carbon emissions, Lishui has a small construction land area and late development, resulting in low total carbon emissions. Despite its economic aggregate ranking last in the province, Lishui effectively leverages its forest background advantages to vigorously develop ecological tourism, ecological industry, and ecological agriculture, striving to realize an "ecological economy and ecological economy," with all indicators at the forefront of the province. However, Zhoushan and Quzhou choose different extensive development paths from Lishui. In port development, Zhoushan faces tight constraints on resources and development space with a rapidly aging population. Quzhou's industrial structure is heavily weighted, and the support force of emerging industries is insufficient, leading to low economic benefits.

Table 9 Spatial Governance Performance Progress Index Ranking of Prefecture-level Cities in Zhejiang Province in 2019 (Compared with 2015)

Overall			**Carbon Emissions**			**Carbon Emissions per Unit of GDP**			**Carbon Emissions Per Capita**			**Carbon Emissions per Unit Area**		
City	Score	Ranking	City	Score	Ranking	City	Score	Ranking	City	Score	Ranking	City	Score	Ranking
Hangzhou	100	1	Hangzhou	100	1	Hangzhou	100	1	Hangzhou	100	1	Hangzhou	100	1
Ningbo	90.09	2	Wenzhou	90.87	2	Ningbo	91.56	2	Ningbo	89.28	2	Wenzhou	91.02	2
Wenzhou	89.99	3	Ningbo	89.62	3	Wenzhou	90.35	3	Wenzhou	86.67	3	Ningbo	90.19	3
Quzhou	86.98	4	Quzhou	87.87	4	Jiaxing	89.32	4	Quzhou	85.14	4	Quzhou	87.87	4
Jinhua	85.84	5	Jinhua	87.01	5	Huzhou	86.93	5	Jinhua	83.92	5	Jinhua	87.01	5
Jiaxing	85.58	6	Jiaxing	85.15	6	Quzhou	85.95	6	Jiaxing	83.20	6	Jiaxing	85.34	6
Huzhou	83.42	7	Huzhou	83.18	7	Jinhua	83.90	7	Huzhou	80.95	7	Zhoushan	84.22	7
Zhoushan	79.45	8	Zhoushan	79.49	8	Taizhou	82.01	8	Zhoushan	76.73	8	Huzhou	83.18	8
Taizhou	79.20	9	Taizhou	79.29	9	Lishui	76.56	9	Taizhou	76.29	9	Taizhou	79.33	9
Lishui	77.37	10	Lishui	77.96	10	Zhoushan	73.60	10	Lishui	76.28	10	Lishui	77.96	10
Shaoxing	55.00	11	Shaoxing	55.00	11	Shaoxing	55.00	11	Shaoxing	55.00	11	Shaoxing	55.00	11

Table 10 Spatial Governance Performance Comprehensive Index Ranking of Prefecture-level Cities in Zhejiang Province in 2019 (Revised)

City	Score	Ranking
Hangzhou	79.63	1
Lishui	71.52	2
Wenzhou	68.83	3
Jinhua	66.44	4
Taizhou	55.03	5
Quzhou	54.21	6
Huzhou	52.06	7
Zhoushan	31.94	8
Ningbo	29.90	9
Jiaxing	29.37	10
Shaoxing	28.30	11

Based on the progress index and comprehensive index of each city, as well as *the 13th national economic and social development five-year plans* of each city, it is evident that Hangzhou and Wenzhou, which achieved rapid carbon emission reduction from 2015 to 2019, demonstrate a high level of comprehensive spatial governance. *Hangzhou's 13th national economic and social*

development five-year plan included optimizing the energy structure and ensuring a clean energy supply. Special planning for ecological and environmental protection, energy development, major construction projects, intelligent manufacturing, industrial and credit economy, and the textile industry was introduced, leading to significant progress in promoting green industrial development. Quzhou implemented *the 13th national economic and social development five-year plan's* content, such as "constructing a high-tech characteristic industrial system, driving the new power of intensive development with innovation, perfecting the system of ecological home building and prioritizing the development of the green, low-carbon circular economy." The situation of heavy industry with high energy consumption and high pollution has been alleviated. However, Quzhou has not issued any special plan for other low-carbon fields except for ecological and environmental protection, and low-carbon reform has not been fully implemented in all aspects. At the same time, Ningbo focused on promoting the industry to the middle or high end, enhancing the core competitiveness of manufacturing and service industries, and formulating special plans for ecological, environmental protection, energy development, and comprehensive transportation. As a result, Ningbo made rapid progress, but its comprehensive level remained low due to its high carbon emission industrial foundation.

Among the cities with slow progress, Lishui has a favorable low-carbon development due to its good background and equal emphasis on environmental protection and ecological and economic development. The development levels of Taizhou and Zhoushan in the province have remained relatively unchanged, while Shaoxing, which was in the middle of the level in 2015, has fallen to the bottom. In summary, the overall spatial governance performance of Zhejiang Province indicates that southwest and central Zhejiang outperform Northeast Zhejiang (Figure 6).

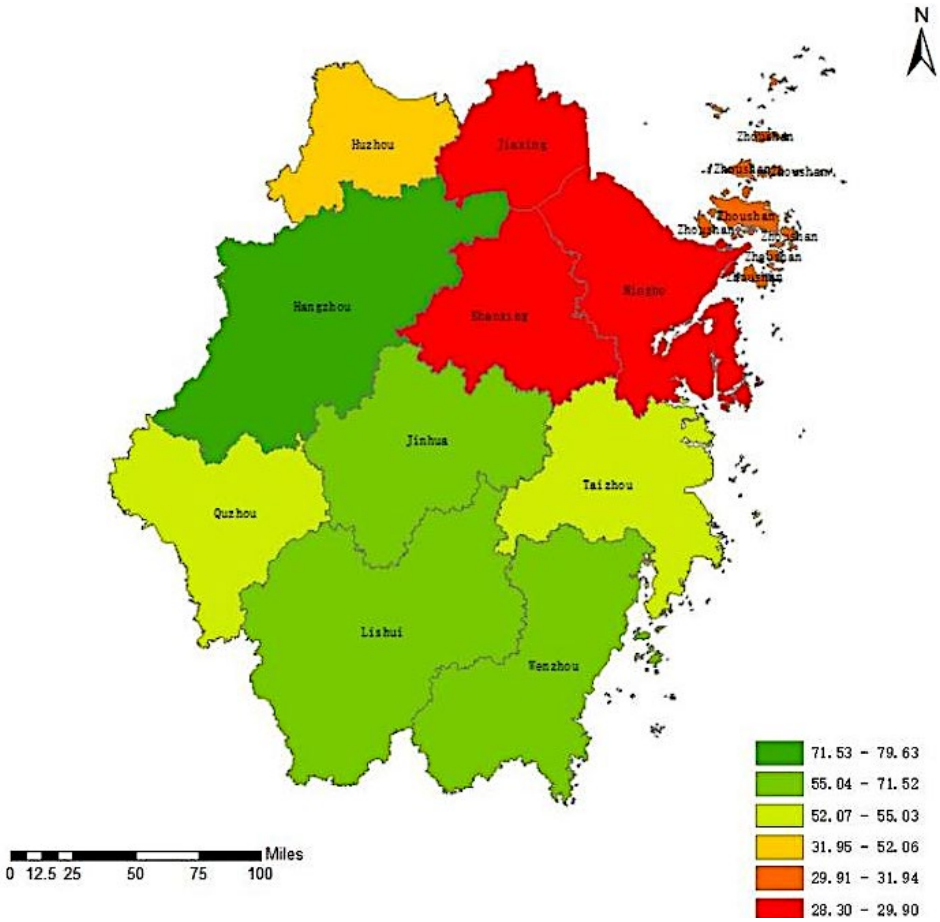

Figure 6 Distribution Map of the Overall Spatial Governance Performance Level of Zhejiang Province in 2019

4.2. Analysis of Carbon-based Differentiated Spatial Control

When analyzing the spatial governance performance level of urban, agricultural, and ecological spaces within the administrative region of prefecture-level cities, net carbon emissions per unit area can not only directly reflect the carbon emission pressure and environmental pressure carried by land per unit area, but also indirectly reflect the degree of industrial greenness and spatial governance level within the space. Therefore, net carbon emissions per unit urban area and net carbon emissions per unit agricultural area are selected as inverse indicators. In contrast, carbon sink per unit ecological area is chosen as a positive indicator.

According to the calculations, in 2019, carbon emissions from urban spaces accounted for 96.14% of the province's carbon emissions, while those from agricultural spaces accounted for 3.86%. The total carbon emissions were 43,178 times the carbon sink generated by ecological spaces. Consequently, the reduction of carbon emissions should focus on urban spaces, and the carbon sink capacity of ecological spaces is generally weak and needs to be further improved. As shown in Table 11, a variance test of carbon emissions per unit area of the three types of spaces in prefecture-level cities in Zhejiang Province indicates that carbon emissions per unit area of urban, agricultural, and ecological spaces showed significant differences in 2015 and 2019 ($p<0.01$). In addition, compared to 2015, the differences among the three types of spaces in 2019 were more pronounced ($F_{2019} > F_{2015}$), suggesting that spatial difference control in Zhejiang Province has achieved initial results. The specific situation of prefecture-level cities will be analyzed in detail below.

Table 11 Variance Analysis Results of Carbon Emissions Per Unit Area in Three Types of Spaces in Prefecture-level Cities in Zhejiang Province

Year	Group (mean±standard deviation)			F	p
	Urban(n=11)	Agriculture(n=11)	Ecology(n=11)		
2015	209.64±67.77	1.34±0.63	-0.00±0.00	104.598	0.000**
2019	213.12±65.69	2.12±1.14	-0.00±0.00	114.621	0.000**

Note：* $p<0.05$，** $p<0.01$

4.2.1. Level Index, Gap Index

Since the connotations represented by the level and gap indexes are consistent, they are analyzed together. As shown in Table 12, Lishui scores the highest in all three types of spaces, while Ningbo scores the lowest in urban space, Wenzhou scores the lowest in agricultural space, and Jiaxing scores the lowest in ecological space. After correcting the above data to a percentage scale, GIS mapping can visually reflect the differences between cities (Figure 7).

Table 12 Spatial Governance Performance Level Index Ranking of Three Types of Spaces in Zhejiang Province in 2019

Urban Space			Agricultural Space			Ecological Space		
City	**Score**	**Ranking**	**City**	**Score**	**Ranking**	**City**	**Score**	**Ranking**
Lishui	83.92	1	Lishui	70.82	1	Lishui	59.27	1
Jinhua	72.31	2	Quzhou	68.37	2	Quzhou	58.11	2
Hangzhou	70.72	3	Huzhou	65.37	3	Jinhua	58.05	3
Taizhou	59.90	4	Shaoxing	61.60	4	Hangzhou	56.17	4
Wenzhou	58.46	5	Jiaxing	61.01	5	Shaoxing	53.61	5
Shaoxing	52.96	6	Taizhou	58.43	6	Wenzhou	53.16	6
Huzhou	52.38	7	Jinhua	57.55	7	Huzhou	53.02	7
Quzhou	47.92	8	Zhoushan	50.13	8	Taizhou	52.71	8
Jiaxing	47.32	9	Ningbo	44.40	9	Ningbo	48.10	9
Zhoushan	39.28	10	Hangzhou	44.02	10	Zhoushan	41.74	10
Ningbo	38.92	11	Wenzhou	25.82	11	Jiaxing	14.27	11

Table 13 Spatial Governance Performance Gap Index Ranking of Three Types of Spaces in Zhejiang Province in 2019

Urban Space			Agricultural Space			Ecological Space		
City	**Score**	**Ranking**	**City**	**Score**	**Ranking**	**City**	**Score**	**Ranking**
Zhejiang	26.08	-	Zhejiang	39.18	-	Zhejiang	50.73	-
Lishui	55.00	1	Lishui	55.00	1	Lishui	55.00	1
Jinhua	43.38	2	Quzhou	52.55	2	Quzhou	53.84	2
Hangzhou	41.80	3	Huzhou	49.55	3	Jinhua	53.78	3
Taizhou	30.98	4	Shaoxing	45.77	4	Hangzhou	51.90	4
Wenzhou	29.54	5	Jiaxing	45.19	5	Shaoxing	49.34	5
Shaoxing	24.04	6	Taizhou	42.61	6	Wenzhou	48.89	6
Huzhou	23.46	7	Jinhua	41.72	7	Huzhou	48.75	7
Quzhou	19.00	8	Zhoushan	34.30	8	Taizhou	48.44	8
Jiaxing	18.39	9	Ningbo	28.58	9	Ningbo	43.83	9
Zhoushan	10.36	10	Hangzhou	28.20	10	Zhoushan	37.47	10
Ningbo	10.00	11	Wenzhou	10.00	11	Jiaxing	10.00	11

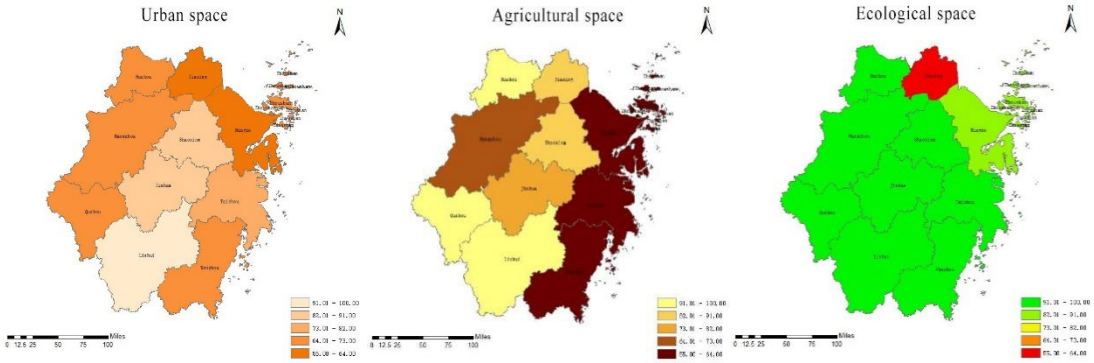

Figure 7-(a). Distribution Map of Spatial Governance Performance Level Index of Three Types of Space in Zhejiang Province in 2015

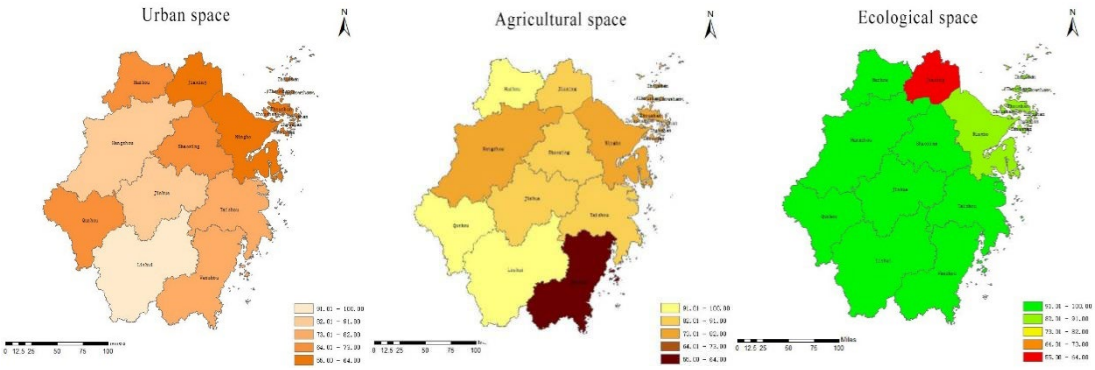

Figure 7-(b) Distribution Map of Spatial Governance Performance Level Index of Three Types of Space in Zhejiang Province in 2019

Lishui, Jinhua, and Hangzhou demonstrate the highest spatial governance performance for urban spaces. Jinhua and Hangzhou continuously optimize the central urban area functions, promote industrial agglomeration, and emphasize the roles of R&D, innovation, management services, and financial services, exhibiting a trend of high-quality green development. In contrast, due to Lishui's small urban space proportion, its ecological industry is the primary focus, with high-end service industries concentrated in the city's core area. Enterprises with high pollution, high energy consumption, and low levels are strictly restricted, resulting in minimal environmental pollution pressure. The spatial governance performance of Jiaxing, Zhoushan, and Ningbo lags, but their economic development levels are at the middle or upper levels of the province. They seize the opportunity for rapid economic development by leveraging their superior coastal geographical position while neglecting the negative impacts of an unfavorable economic development mode on the urban spatial environment and low-carbon development. Among them, Ningbo has numerous high-energy-consuming enterprises, which significantly constrain urban spaces' green and high-quality development.

For agricultural spaces, according to Zhejiang Province's agricultural distribution, the spatial governance performance of most agriculturally concentrated areas, such as Quzhou, Huzhou, Shaoxing, and Jiaxing, ranks in the middle or upper levels of the province. This is related to the strong guarantee and support provided by basic natural resources and intensive resource utilization. Huzhou, for example, leads in implementing China's agricultural "standard place" reform. The integration of green development in the agricultural industry has achieved remarkable results, winning the province's comprehensive evaluation of agricultural and rural modernization development for six consecutive years and becoming the province's model area for beautiful rural areas in the new era. Lishui, a mountainous and hilly city, is limited by terrain

and topography and has a small agricultural space proportion. It mainly relies on ecological agriculture and ecotourism to support rural revitalization, so the carbon emission pressure is low. Hangzhou, Ningbo, and Zhoushan have low levels of agricultural industry chains and rural population losses to urban spaces, leading to the lagging development of agricultural spaces. Although Wenzhou is also an agricultural concentration area, its cultivated land area as a carbon source is much larger than the orchard area as a carbon sink, and its agricultural natural endowment level, scientific and technological innovation level, and economic benefits are lower. Compared to developed areas, there are still significant gaps in agricultural labor productivity and per acre yield rate, severely affecting agricultural spaces' sustainable development.

For ecological spaces, Lishui has high forest coverage, a large proportion of ecological space, and minimal environmental pollution, providing a favorable background for the healthy development of ecological spaces. In contrast, the ecological space of Jiaxing is fragmented, with a very low forest coverage rate, heavy environmental pollution, and severely insufficient carbon sink capacity.

4.2.2. Progress Index

This paper takes 2015 as the reference year and mainly explores the spatial governance performance progress of various prefecture-level cities in Zhejiang Province during the 13th Five-Year period. As shown in Table 14, Hangzhou, Taizhou, and Jiaxing are the cities with the fastest progress in urban, agricultural, and ecological spaces. The cities with the slowest progress are Shaoxing, Wenzhou, and Lishui.

Table 14 Spatial Governance Performance Progress Index Ranking of Three Types of Spaces in Zhejiang Province in 2019 (Compared with 2015)

Urban Space			Agricultural Space			Ecological Space		
City	**Score**	**Ranking**	**City**	**Score**	**Ranking**	**City**	**Score**	**Ranking**
Zhejiang	85.25	-	Zhejiang	77.66	-	Zhejiang	55.56	-
Hangzhou	100.00	1	Taizhou	100.00	1	Jiaxing	100.00	1
Jiaxing	91.47	2	Zhoushan	92.64	2	Zhoushan	56.48	2
Wenzhou	89.87	3	Shaoxing	79.77	3	Ningbo	56.27	3
Jinhua	81.03	4	Ningbo	79.30	4	Taizhou	55.94	4
Ningbo	80.66	5	Jinhua	78.65	5	Wenzhou	55.84	5
Huzhou	80.26	6	Huzhou	76.93	6	Hangzhou	55.74	6
Quzhou	79.53	7	Lishui	75.24	7	Huzhou	55.65	7
Taizhou	77.72	8	Quzhou	75.21	8	Shaoxing	55.58	8
Lishui	75.79	9	Jiaxing	73.96	9	Jinhua	55.24	9
Zhoushan	75.10	10	Hangzhou	70.76	10	Quzhou	55.19	10
Shaoxing	55.00	11	Wenzhou	55.00	11	Lishui	55.00	11

As illustrated in Figures 8 and 9, the spatial governance performance of urban, agricultural, and ecological spaces in Zhejiang Province's prefecture-level cities improved from 2015 to 2019, with

the progress of ecological spaces being relatively modest. Consequently, attention should be directed toward enhancing carbon sink capacity in the next stage. Nonetheless, prefecture-level cities with high spatial governance performance maintained a relatively stable progress trend, remaining at the forefront of the province in 2019. Mid-level prefecture-level cities exhibited a lack of development momentum, and most experienced a decline in 2019. However, the cities with low levels in 2015 generally demonstrated notable progress, but due to their weak foundation, they still ranked in the middle or lower levels in 2019.

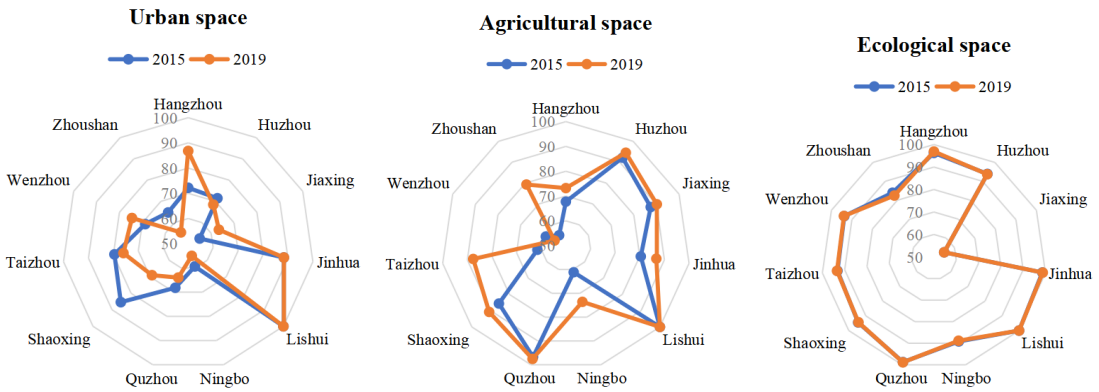

Figure 8 Comparison of the Level Index of Prefecture-level Cities in Zhejiang Province between 2015 and 2019

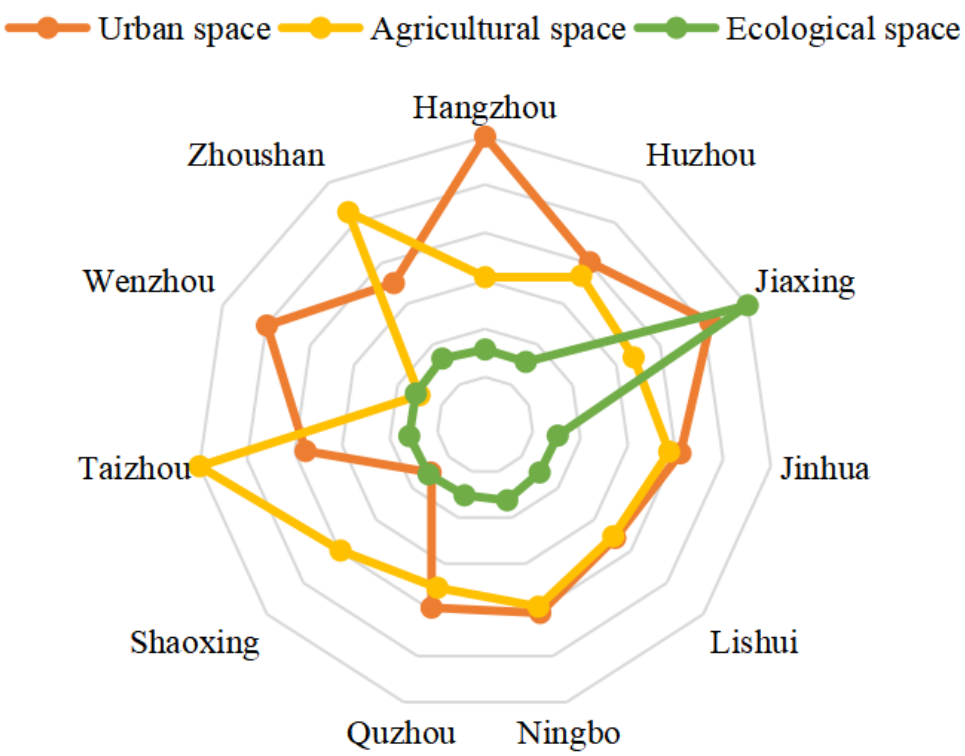

Figure 9 Radar Chart Showing the Spatial Governance Performance Progress Index of Different Types of Spaces in Prefecture-level Cities in Zhejiang Province in 2019

4.2.3. Comprehensive Index

By integrating the three perspectives of "level, progress, and gap", the comprehensive index can comprehensively and effectively analyze the spatial governance performance level and differentiated control effect of prefecture-level cities in Zhejiang Province. The low overall value of the comprehensive index is due to the low values of the level index and gap index multiplied by the correction index (progress index). Therefore, the data has been adjusted to a percentage basis (Table 15).

Table 15. Spatial Governance Performance Comprehensive Index Ranking of Three Types of Spaces in Zhejiang Province in 2019 (Revised)

Urban Space			Agricultural Space			Ecological Space			Overall		
City	Score	Ranking	City	Score	Ranking	City	Score	Ranking	City	Score	Ranking
Hangzhou	75.55	1	Taizhou	75.79	1	Lishui	48.57	1	Lishui	62.54	1
Lishui	69.18	2	Lishui	69.87	2	Quzhou	47.53	2	Jinhua	53.67	2
Jinhua	59.03	3	Quzhou	66.41	3	Jinhua	47.52	3	Taizhou	52.31	3
Wenzhou	46.14	4	Huzhou	64.05	4	Hangzhou	46.01	4	Hangzhou	50.31	4
Taizhou	38.70	5	Shaoxing	61.49	5	Shaoxing	43.05	5	Quzhou	45.78	5
Huzhou	30.11	6	Jiaxing	54.88	6	Wenzhou	42.83	6	Huzhou	45.55	6
Jiaxing	29.44	7	Zhoushan	54.57	7	Huzhou	42.48	7	Shaoxing	39.45	7
Quzhou	23.39	8	Jinhua	54.44	8	Taizhou	42.43	8	Jiaxing	31.71	8
Shaoxing	13.82	9	Ningbo	35.67	9	Ningbo	37.68	9	Zhoushan	31.59	9
Ningbo	11.28	10	Hangzhou	29.38	10	Zhoushan	30.85	10	Wenzhou	29.72	10
Zhoushan	9.36	11	Wenzhou	0.18	11	Jiaxing	10.82	11	Ningbo	28.21	11

As depicted in Figure 10, the spatial governance performance of prefecture-level cities in Zhejiang Province exhibits distinct regional characteristics. Specifically, the development levels in central and southwest Zhejiang are significantly higher than those in northeast Zhejiang, with inland cities outperforming coastal cities. It may be attributed to the Hangzhou metropolitan area in central Zhejiang, which boasts robust economic strength, thriving tourism, and a well-balanced industrial structure. The provincial strategy also prioritizes the Hangzhou Bay area. Capitalizing on its high spatial governance level, Hangzhou effectively leverages its spatial radiation effect, promoting the sound development of neighboring Jinhua, Quzhou, and Huzhou. Lishui, situated in southwest Zhejiang, benefits from the late development of urban and agricultural spaces, high forest coverage rate in ecological spaces, and minimal environmental pollution, resulting in a solid foundational background and low environmental pressure. Conversely, Jiaxing, Zhoushan, Wenzhou, and Ningbo cities initially exploited their coastal location advantages for excessive economic and agricultural development, leading to unreasonable industrial structures in urban and agricultural spaces, severe environmental pollution, insufficient innovation-driving forces, energy consumption, and waste, and a weak carbon sink basis in ecological spaces, ultimately resulting in low spatial governance performance.

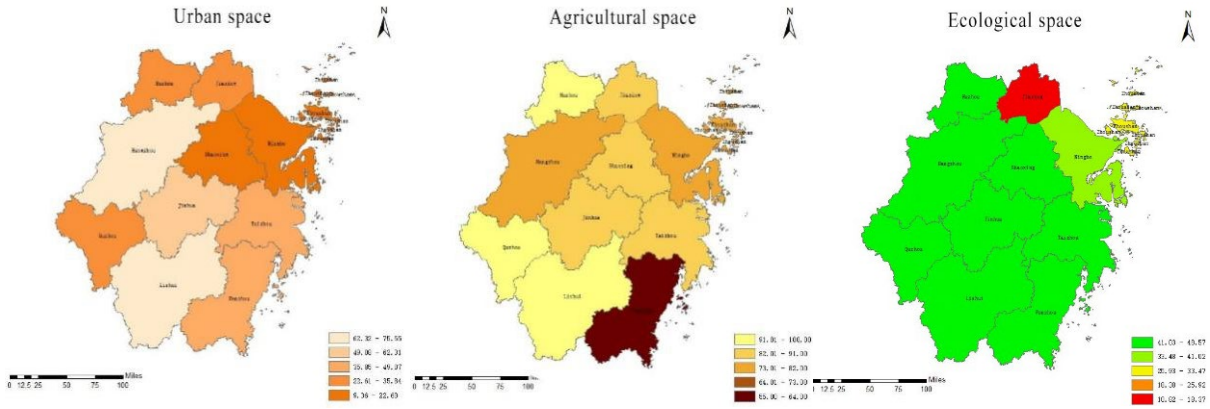

Figure 10. Distribution Map of Spatial Governance Performance Comprehensive Index of Different Types of Spaces in Prefecture-level Cities in Zhejiang Province in 2019

4.3. Evaluating the Spatial Governance Performance in Zhejiang Province

Differentiated control and evaluation of urban, agricultural, and ecological spaces can efficiently identify the strengths and weaknesses of various spaces, thereby better guiding the development and utilization of government, enterprises, society, and other stakeholders, as well as spatial protection activities and resource coordination. Consequently, differentiated spatial governance lays a blueprint for China's territorial space development, and guides coordinated development. This paper employed an indicator system based on carbon to study the effects of differentiated spatial governance and low-carbon development in Zhejiang Province through literature analysis and case analysis.

The study finds that economic development modes, environmental quality, and planning in different prefecture-level cities in Zhejiang Province have considerable disparities in their impact on carbon emissions. The overall spatial governance performance of southwest and central Zhejiang outperforms that of northeast Zhejiang. In most prefecture-level cities, one or two spatial governance levels across urban, agricultural, and ecological spaces are not high, resulting in unbalanced and insufficient development. Various cities' spatial planning and management require differentiated management and control based on specific circumstances. Hangzhou, Ningbo, and other large cities with high population density and land utilization rates need to enhance efficient space utilization and planning methods for urban spaces to elevate the industrial level. They must also improve public transport facilities and strengthen the protection of the ecological environment to enhance urban sustainability and residents' quality of life. Coastal cities such as Zhoushan and Taizhou, endowed with abundant marine resources and unique geographical advantages, should employ scientific methods for marine space utilization and management, safeguard marine ecological environments and resources and develop marine economy and tourism. Small and medium-sized cities like Shaoxing must focus on comprehensive planning and management, emphasizing the city's cultural environment and historical and cultural characteristics while rationally utilizing land resources to foster urban economic development and social progress. Lishui, possessing a unique natural ecological environment, should prioritize ecological protection and restoration, promoting the recovery and development of forests, grasslands, wetlands, and other natural ecosystems, and cultivating ecological agriculture, characteristic tourism, cultural creativity, and other industries to enhance industrial development quality and efficiency. Therefore, the spatial governance system of Zhejiang Province should further improve the spatial planning system, refine the laws and regulations system, and fully harness the institutional synergy of "overall planning + rigid laws and regulations + flexible policies". Moreover, Zhejiang should adapt to local conditions and jointly advance the enhancement of spatial governance capabilities and the integration and

implementation of low-carbon development from multiple perspectives and levels of departmental coordination, action coordination, and target coordination.

5. CONCLUSION

Since carbon emissions encompass a wide range of areas and the spatial governance system is still under construction, this paper's data and research methods are limited, resulting in certain shortcomings. Future research and analysis can be conducted from the following aspects: (1) The carbon emission per unit area only reflects ecological, environmental pressure in space but cannot comprehensively address GDP benefits, development equity, and other issues. In the future, the carbon-centered governance performance indicator system can be further improved to evaluate spatial governance levels more comprehensively. (2) Besides the coefficient of variation method, subjective and objective methods such as comprehensive index, data envelopment analysis, and analytic hierarchy process can also be utilized to determine indicator weights. In the future, a combination of subjective and objective methods can be employed for indicator weight determination. (3) The research perspective can be extended to counties to explore the vertical collaborative mechanism of spatial governance at the provincial, city, and county levels. (4) Establish an evaluation system for the effectiveness of spatial governance and low-carbon development policies to align policy implementation with changes in the status quo. (5) Simulate carbon emission reduction scenarios under different spatial governance to provide detailed spatial governance policy path references and suggestions for the "two-carbon target" provide detailed spatial governance policy path references and suggestions for the "dual carbon targets".

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EVALUATING INSURANCE FUNDS AS A FINANCING SOURCE FOR INFRASTRUCTURE DEVELOPMENT: A CASE STUDY OF INDONESIA

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ABSTRACT

There is a funding deficit that cannot be covered by relying solely on government money to build Indonesia's Infrastructure; consequently, additional sources of financing are engaging the private sector to fill the gap. Insurance funds are an alternative funding source in many countries, although their application is still at an early stage. By assessing the risks faced by insurance companies involved in infrastructure investment, this paper attempts to evaluate the use of insurance money as an alternative funding source for infrastructure investment in Indonesia. The analytical hierarchical process (AHP) technique was used in the quantitative methodology of this study to evaluate the risks faced by insurance companies when investing in infrastructure and to identify strengths and limitations. The results show that insurance funds are a possible alternative funding source for infrastructure projects in Indonesia; as a result, the government provides the necessary instruments, such as important policies and attractive partnership structures and models.

Keywords: Alternative financing; Infrastructure; Insurance funds; AHP analysis

1. INTRODUCTION

Infrastructure enhancement is crucial for increasing a nation's economic progress. By providing connectivity to facilitate people and mobilize goods from one place to another, infrastructure can reduce the effect of distance between regions, further interconnecting the economic activities in the areas, achieving efficiency, and improving productivity. Infrastructure development covers numerous sectors, such as public utilities (power, generation, water, and gas supply), public works (roads, dams and canals, tunnels, water treatment supplies), public transport (urban transport systems, railways, airports, bridges, and tunnels) (Grimsey & Lewis, 2002; Susantono & Berawi, 2015).

Since 2011, the Indonesian government has designated improving national connectivity as one of its tactics to promote business activity growth along economic corridors; thus, various initiatives for developing investment activities have been carried out in many infrastructure projects. However, the Indonesian National Development Planning Agency (BAPPENAS) calculated that only 37% of the necessary expenditures could be covered by the state budget,

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leaving a gap in funding that needs to be covered by alternative non-government resources (Berawi, 2017), involving private sectors through public-private partnership (PPP) financing schemes.

The utilization of insurance funds for infrastructure development has been implemented in some countries (Gatzert & Kosub, 2014). For insurance companies, investing in infrastructure has been seen as an attractive asset class with the combined characteristics of equity, debt, and real estate (Weber et al., 2016). The potential for favorable risk-adjusted returns on equity investments, long-term exposure to risk-matched long-term liabilities, illiquidity, and industry variety make them desirable for portfolio insurers (EY, 2015).

However, despite the growing interest among insurance companies (Gatti, 2014), Infrastructure investments have particular risk profiles due to the construction risk, high running leverage, limited market competition, and high degrees of asset specificity (Rothballer & Kaserer, 2012). Besides, investments in infrastructure are difficult to be assessed in terms of the risk/return ratio due to the high costs, limited liquidity, and long asset life (Blanc-Brude et al., 2016).

In addition to that, institutional and political factors such as the limitation on the transparent and stable regulatory framework, the unfocused long-term vision for the development of infrastructure, and limited institutional facilitation from the government have also been the causes for the slow adoption of institutional investors to participate in the investment of infrastructure development (Croce & Gatti, 2015; Verhoest et al., 2015).

In previous research, many identifications of risk factors due to infrastructure-related disasters were carried out. Insurance and mitigation measures are an efficient solution to reduce disaster losses and speed up recovery time (Tonn et al., 2021). In infrastructure development in India, non-life insurance companies significantly contribute to infrastructure investment (Babu & Rao, 2015). Insurance can also be a source of infrastructure investment funding due to the ability of the insurance industry to generate income even during a pandemic (Larasati et al., 2022). However, there are still many constraints and ineffectiveness in its application, one of which is due to the need for clear identification of risks for insurance companies investing in infrastructure projects.

The prospect of insurance funds in financing Indonesian infrastructure projects is still in its infancy. It has been explored through the efforts of the Non-Government Budget Equity Financing (PINA) program carried out in 2017-2019 to facilitate the participation of private sectors, particularly the utilization of long-term managed funds such as life insurance and pension funds to achieve national infrastructure development targets. Therefore, this paper aims to analyze the utilization of insurance funds as an alternative financing source for infrastructure development in Indonesia by evaluating the risks faced by insurance companies participating in infrastructure investment. This research also seeks to promote the potential of insurance funds for infrastructure financing and increase private participation, particularly insurance companies, in infrastructure investment. Other countries can use the results of this study to assess investment in insurance funds in the infrastructure sector to accelerate development.

2. LITERATURE STUDY

2.1. Insurance

According to the Indonesian Commercial Law Code (KUHD) article 246, insurance is an agreement. By accepting the premium from the insured, the insurer commits to pay him for any anticipated loss, damage, or loss of profits he may incur due to an unspecified event. According to (Abbas, 2007), insurance is a willingness to determine certain small failures as a substitute for large uncertain losses.

According to the Law of the Republic of Indonesia Number 2 of 1992 concerning the insurance business, insurance is an agreement between two or more parties in which the insurer guarantees himself to the insured party, called an insurance agreement, or transfers the right of responsibility to a third party who may make the insured suffer hardship as a result of uncertain events, or provide reimbursement based on the death or survival of the insured person. This kind of insurance is called life insurance, which helps protect individuals or their relatives who are left behind after a death or permanent injury (Bakar et al., 2018). From the economic aspect, insurance is a method used to reduce risks by transferring them and combining the uncertainty of a financial loss with other parties (Darmawi, 2006).

There are many benefits yielded by having insurance in a business, such as: (1) protecting business from investment risk and uncertainty; (2) being an alternative source coming from non-bank financial institutions that assemble public funds for investment; (3) increasing creditors' trust by having the business insured from investment risks; (4) lessening concerns as it reduces the uncertainty of the economic burden from the uncertain losses; (5) reducing capital costs owing to the high rate of return (RoR) of the invested capital; (6) ensuring company stability by having the employees insured; (7) stabilizing the business profits since incidental costs have been considered; (8) provision of professional services that are more engaged in technical fields to do business operates properly and efficiently; (9) encouraging efforts to prevent losses by minimizing the possibility; and (10) promoting healthcare (Darmawi, 2006).

2.2. Insurance Funds for Infrastructure Financing

The Insurance industry offers a wide range of products, including annuity, life, health, and reinsurance products (Baranoff & Sager, 2002). In the context of finance, the role of insurance businesses can be assessed in terms of the accumulation of reserve funds created by insurance businesses. Life insurance premiums, for example, are usually paid every year for life. Since the probability of death is initially low and will increase as a person ages, the premium received by a life insurance company at first is more than enough to cover the early years. Thus, insurance reserves are funds collected from excess premiums on claims plus compound interest required to ensure future insurance compensation payments, which consist of emergency funds, mathematical reserves of life insurance policies, unpaid claims, premiums received in advance, and other reserves determined by the insurance company (Raeva & Pavlov, 2017). After being reduced by operating expenses, these funds are deposited in banks or invested in certain businesses that are considered economically profitable, making the investment function extremely important in the operation of an insurance company (Chui & Kwok, 2008). The reserve funds of insurance companies encourage efforts to increase national savings and promote the fulfillment of investment funds in the industrial sector, both directly and through capital market instruments.

According to Syahrir (1996), insurance companies are faced with various risks in the investment process, such as; (i)financial risk, in which the debtors/issuers of shares have financial difficulties in paying the lenders/creditors/investors; (ii) interest rate risk, in which the changes in general interest rates prevailing in the market can affect the investment interest or market value of shares; (iii) purchasing power risk, in which the changes in commodity price levels, living costs, consumer price indexes, and inflation rates can reduce investment returns, (iv) liquidity risk, in which the amount of investment can be converted into cash, and some large shares can be marketed, and (v) market risk, in which the decline of investment returns is due to economic recession, war, structural changes, and changes in consumer preferences. In investing life insurance and pension funds in infrastructure projects, risk is an issue that all stakeholders must consider to understand the specific risks in infrastructure better. Risks related to infrastructure

investment include liquidity, price, time, government, management, and operations (Inderst, 2009).

Several main factors cause the amount limitation for investment funds from insurance companies in Indonesia; the first factor is that the insurance business requires a large capital because it must be accounted for the risk of fire, death, disaster, and so on; the second one is that the monetary conditions still provide relatively large investments in deposits. Lastly, there are still constraints for insurance companies to invest in shares.

2.3. Implementation of Insurance Fund for Infrastructure Financing

2.3.1. China

The practice of insurance funds for infrastructure investment was already regulated since 2006 in China; it was upon the approval of the State Council that the insurance funds were allowed to be invested in infrastructure projects following the issuance of Regulation Number 1 of 2006 by the China Insurance Regulatory Commission (CIRC) concerning the guidelines and administrative steps for pilot indirect investments of insurance fund in the infrastructure projects which aimed to regulate the investment of insurance fund in the real estate sector particularly to manage investment risk, to protect the asset, and to guarantee the rights of the insurers and insured.

The early notion of insurance funds in China's infrastructure investment in 2010 included the land provision projects done by the government both through debt and equity schemes. After some time, the Provisional Government Regulation on Infrastructure Debt Investment Plans took its position (CIRC Order No. 92 of 2012) (Calder & Min, 2012). Investors entrust the funds to the investment management of the infrastructure project, which will provide an infrastructure debt investment plan following the investors' objectives.

In 2016, CIRC revised the Pilot Measures for the Administration of Indirect Investment in Infrastructure Projects by Insurance Funds issued in 2006, intending to further develop asset management in the insurance industry. The revisions include simplifying the procedure of regulatory administration, eliminating administrative approval relating to an investment in infrastructure projects by insurance funds, and expanding the investment range: escalating the applicable industries and feasible models for investing insurance funds in infrastructure projects (Hogan Lovells, 2016).

2.3.2. Australia

Infrastructure financing from insurance and pension funds began in 2002 at around 2% of total funding in Australia. The Australian government slashed its infrastructure spending from more than 14% in 1970 to 5% in 2005. This also allowed insurance and pension funds to spend more on infrastructure, potentially displacing the government as the main funder of these projects.

Australia already has regulations regarding the investment process that mandate that trustees can discharge their responsibilities and that appropriate risk management mechanisms must be in place to monitor, manage and control risk exposure. The Australian system allows regulators to change capital or fee requirements in volatile markets (OECD, 2015).

2.3.3. United Kingdom

The PPP model in the UK has involved the construction industry during the planning, construction, and operation stages of a newly built road. A more comprehensive concept was created in 1997, enhancing the Private Finance Initiative (PFI) model introduced in 1992. This

plan covers infrastructure development, particularly in transit, health, education, housing, home construction, military, information technology (IT), wastewater management, and sanitation.

There are about 15 public and private funds that participated in infrastructure investment in the UK, in which some of which are large insurance and pension fund companies such as:

1) The London Pensions Fund Authority (LPFA) is the largest local government pension scheme fund. LPFA has 5%-15% of its investment portfolio allocated for infrastructure investment. This investment aimed to generate decent risk-adjusted returns through improved diversification of infrastructure assets located in various countries. The investment was made through several instruments such as direct investment, investment financial institutions, and in part, investment institutions listed on the stock exchange, and it also sought to offer certain cash flow and indirectly limit against inflation (LPFA, 2018).
2) Universities Superannuation Scheme (USS) is the second largest investor of insurance funds for infrastructure after LPFA. A percentage of 90% of USS's capital is placed in investment financial institutions, and the remainder is through direct investment. Since early 2007, USS has begun investing in private equity, commodities, and infrastructure. These investment placements and hedge funds will eventually result in an alternate 20% share in the total assets of the pension fund. Over the last five years, USS has globally deployed about £3 billion in real assets and executed around 15 transactions (USS, 2019).
3) Greater Manchester Pension Fund (GMPF) is the largest domestic insurance and pension fund in the UK, consisting of 10 regions in Manchester and around 200 related organizations. As of 2019, the total GMPF's fund amounted to £22,891 million. The current GMPF fund allocation target is realistically allocated 4%, 0.5%, and 2.5%, respectively. The objective allocation for private equity, private debt, and infrastructure funds is 5% of the primary fund value. The infrastructure investment started in 2001, and the value of assets currently invested in infrastructure as of March 31, 2019, was approximately £593 million, with improved inception performance to an annualized return of 10.9% per year (GMPF, 2019).

2.3.4. Canada

The authority for infrastructure development in Canada is given to each province, and despite the different regulations, they all have made efforts to increase the use of PPPs which have made up to 10% to 20% of Canada's infrastructure spending (Iacobacci, 2010). The region that has the clearest application of PPP is British Columbia, followed by Quebec, which has recently revised its regulations to attract more investment.

The Canadian insurance industry, which has been playing a significant role in providing longer-term finance (Kranc, 2012), has also participated in infrastructure investment, amounting to more than 3% of the total assets. There are more than 15 companies of state-owned and private insurance and pension funds that have invested in the infrastructure sector in Canada. These insurance companies invested their funds in the infrastructure sector both through direct investment in the infrastructure companies and the infrastructure company's shares. Some of the insurance companies that have an important role in Canada's infrastructure sector investment include:

1) The Ontario Teachers' Pension Plan (OTTP), which is one of the largest public pension funds, has been investing directly in infrastructure since 2001, with a focus on majority or joint controlling shares using an active governance strategy. Geographically, in terms of growth stage and in terms of business, the infrastructure stock varies. Airports, cargo

hubs, power generation, transmission, and initiatives for green energy production are some of the areas where assets are addressed (Burgess, 2020).

2) Ontario Municipal Retirement System (OMERS), is a financial institution created back in 1962 for government employees in Ontario. As of Dec 2017, investment in infrastructure represented 10.6% of the total assets in the funds of about USD 82 billion (Walker, 2019). OMERS infrastructure, investing in infrastructure assets globally on behalf of OMERS, has a diversified portfolio of large-scale infrastructure assets that exhibit stability and strong cash flows, including the energy sector, transportation sector, and government-regulated services.
3) Canadian Pension Plan (CPP) is an insurance company engaged in life insurance and retirement that began investing in the infrastructure sector in 2005 and developed a portfolio of direct investment and started commitments with financial institutions that invest funds in the infrastructure sector. At the end of 2010, an investment portfolio for the infrastructure sector was planned to reach 6.5% of their portfolio (BBVA, 2008).

3. METHODS

The research methodology followed these systematic steps, namely the expert validation questionnaire survey and the analysis of the results of the questionnaire survey using the AHP method. The proposed research workflow can be seen in Figure 1.

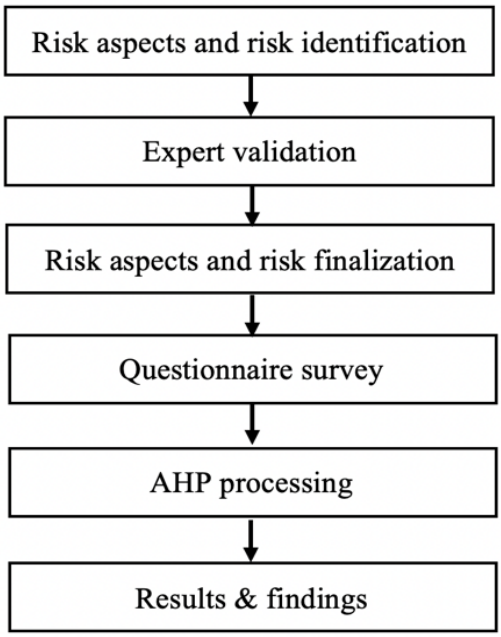

Figure 1 Research Workflow

First of all, the research variables were identified based on the investigation from journals, books, and regulations (Berawi et al., 2018; Berawi & Woodhead, 2008) regarding the risk aspects faced by insurance funds in infrastructure investment. The research variables will be validated through experts in insurance, development funding, and infrastructure financing as a reference and input, as well as suggestions for research variables so that the questionnaires are more targeted. This research identified the main risks that should be considered for infrastructure investment using insurance funds after consulting with Indonesian authorities in law and regulation, infrastructure, risk and finance, and transportation planning to assess these risks.

These validated variables were then sent to twenty respondents representing regulators, insurance practitioners, and infrastructure experts in the form of questionnaires. The purposive selection was used to select these interviewees, identifying those with the most knowledge and experience (Miles & Huberman, 1994), particularly in regulation, insurance, and infrastructure, with minimum requirements of holding a bachelor's degree and more than ten years of experience in insurance or infrastructure industry. Of twenty respondents, eight respondents represented regulators, nine respondents represented insurance practitioners, and three respondents represented infrastructure experts.

The results from the questionnaire survey were then analyzed using the analytical hierarchy process (AHP) method to evaluate the risks. AHP has been used by researchers and academics because of its adaptive application, among others, with fuzzy logic and linear programming (Vaidya & Kumar, 2006), as well as its simplicity, consistency logic, priority measurement, and process repetition (Saaty, 1980). This method combines mathematics and psychology in a structured and organized way to evaluate complex problems (Saaty, 2008). It uses qualitative and quantitative approaches to come up with a final decision. The multi-level hierarchical framework used in qualitative methods helps visualize problems (Crowe et al., 1998; Wong & Li, 2008), while the quantitative approach selects essential factors to less critical factors using a scaling system (Cheung et al., 2001; Ucler, 2017). When the problems and expected objectives were already identified, a hierarchical system was used to organize them down to the potential choices. To evaluate each element at each criteria level, a pairwise comparison was proposed using an intensity scale of importance, as shown in Table 1 below.

Table 1 Intensity Scale of Importance

Scale Value	Definition	Explanation
1	Equal	Two elements equally
3	Moderate	An element is slightly more important than another
5	Strong	An element is definitely important over another
7	Very Strong	An element is definitely very strongly important over another
9	Extreme	An element is more important than another
2,4,6,8	Intermediate between values	A numerically interpolated compromise judgment

Questionnaires filled out by respondents were analyzed using the AHP method and produced rating weights for each variable in the risk area. Respondents filled out a survey form with an importance scale from 1 to 9. The results of the questionnaires, which were processed using multi-criteria decision analysis, showed that for the goal decision is insurance fund as an alternative infrastructure financing, the level 1 criteria consist of constraints and potencies of investing insurance fund for infrastructure projects, while the level 2 criteria consist of the role and responsibilities of the government (GOV) and private (PTE) and the level 3 criteria consists of all risks (AR), most risks (MR), and evenly distributed risks (EDR), as can be seen in Figure 2.

To evaluate the hierarchical priorities of the criteria and the variable risks for infrastructure investment by insurance funds based on the identified risk aspects, eigenvalue, and consistency tests were conducted. A consistency ratio (CR) was used in the consistency exam to assess the degree of inconsistent judgment, with a CR of less than 10% typically being regarded as acceptable. The role and responsibilities that should be borne both by the government and the private sectors as investors were also determined using this analysis. And lastly, the AHP method was also used to analyze the constraints and potentials of insurance fund investment in infrastructure in Indonesia.

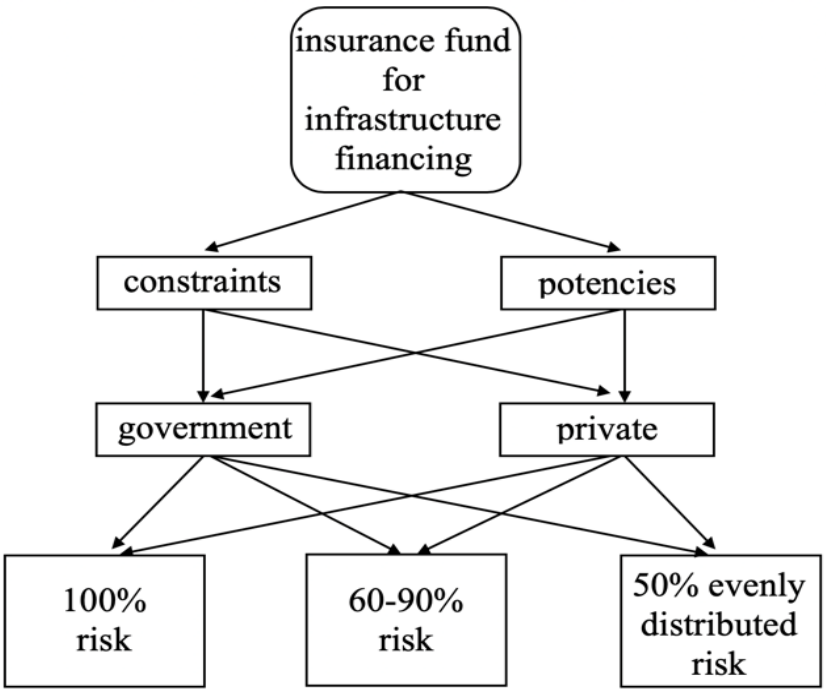

Figure 2 Hierarchy of Insurance Fund for Infrastructure Financing

4. RESULTS AND DISCUSSION

After the variables were identified based on the literature review conducted, they were then validated by the experts. These validated variables involved four risk aspects, including financial risk, political risk, liquidity risk, and market risk. Financial risk consists of five variables, namely, the debtors' ability to return loans, changes in the price level, changes in interest rate, insurance investment portfolios more into short-term investments, and changes in insurance industry assets. Political risk consists of five variables that include unclear insurance regulations for infrastructure financing, investment restrictions regulation, insurance fund more as alternative financing, government policies that often change, and tax increases. Liquidity risk consists of three variables that include a level of solvency and liquidity, project financing flexibility, and lapse rate. And there are three variables in market risk, namely limited information on insurance investment in infrastructure projects, economic growth, and unfavorable investment climate.

4.1. Constraints and Potencies of Insurance Fund Investment in Infrastructure

The result of the AHP analysis for level 1 showed that all criteria of insurance funds' investment risk parameters have a consistency ratio (CR) of less than 10%, meaning that all variable values are acceptable. The highest number of analysis findings indicates the choice for that specific hazard. For example, variable X1, with the debtors' ability to return loans, is considered a constraint since its value is higher than the value of potency. Meanwhile, variable X9, with government policies that often change as one of the political risks, is considered as a constraint, and variable X11, with the level of solvency and liquidity as one of the liquidity risks, is regarded as potency. An unfavorable investment climate as one of the market risks is considered a constraint (see Table 2).

Table 2 AHP Analysis Result (Level 1)

Variable	Insurance Funds' Infrastructure Investment Risks	Analysis Result		Consistency Ratio
		Constraint	Potencies	
Financial Risk				
X1	The debtors' ability to return loans	**0,833**	0,167	0
X2	Changes in the price level	0,250	**0,750**	0
X3	Changes in interest rate	**0,857**	0,143	0
X4	Insurance investment portfolios are more into short-term investments	**0,900**	0,100	0
X5	Changes in insurance industry assets	**0,889**	0,111	0
Political Risk				
X6	Unclear insurance regulations for infrastructure financing	**0,889**	0,111	0
X7	Investment restrictions regulation	**0,857**	0,143	0
X8	Insurance funds more as an alternative financing	0,250	**0,750**	0
X9	Government policies that often change	**0,889**	0,111	0
X10	Tax increase	**0,833**	0,167	0
Liquidity Risk				
X11	Level of solvency and liquidity	0,125	**0,875**	0
X12	Project financing flexibility	0,143	**0,857**	0
X13	Lapse rate	**0,857**	0,143	0
Market Risk				
X14	Limited information on insurance investment in infrastructure projects	**0,889**	0,111	0
X15	Economic growth	0,111	**0,889**	0
X16	Unfavorable investment climate	**0,857**	0,143	0

4.2. Role and Responsibilities of the Government and Private Sector

Likewise, the result of the AHP analysis for level 2 showed that all criteria of insurance funds' investment risks have a consistency ratio (CR) of less than 10%, which means that all values of all variables from four identified risks can be accepted.

Based on the highest value of the analysis results, the variables in financial risk considered as the government's responsibilities are the changes in interest rate (variable X1); meanwhile, the other variables, such as changes in the price level, changes in interest rate, insurance investment portfolios more into short-term investments and changes in insurance industry assets are considered as private sectors' responsibilities.

The values of analysis results for all variables in the political risks show that all five variables are considered as the government's responsibilities. Furthermore, the variables both in liquidity and market risks, which include the level of solvency and liquidity, project financing flexibility, lapse rate, Limited information on insurance investment in infrastructure projects, economic growth, and unfavorable investment climate, are considered as the responsibilities that are addressed to the government (see Table 3).

Table 3 AHP Analysis Result (Level 2)

Variable	Insurance Funds' Infrastructure Investment Risks	Analysis Result		Consistency Ratio
		GOV	PTE	
Financial Risk				
X1	the debtors' ability to return loans	0,125	**0,875**	0
X2	changes in the price level	0,111	**0,889**	0
X3	changes in interest rate	**0,833**	0,167	0
X4	insurance investment portfolios are more into short-term investments	0,167	**0,833**	0
X5	changes in insurance industry assets	0,143	**0,857**	0
Political Risk				
X6	unclear insurance regulations for infrastructure financing	**0,857**	0,143	0
X7	investment restrictions regulation	**0,857**	0,143	0
X8	insurance fund more as an alternative financing	**0,833**	0,167	0
X9	government policies that often change	**0,875**	0,125	0
X10	tax increase	**0,857**	0,143	
Liquidity Risk				
X11	level of solvency and liquidity	**0,857**	0,143	0
X12	project financing flexibility	**0,900**	0,100	0
X13	lapse rate	**0,889**	0,111	0
Market Risk				
X14	Limited information on insurance investment in infrastructure projects	**0,875**	0,125	0
X15	economic growth	**0,800**	0,200	0
X16	unfavorable investment climate	**0,875**	0,125	0

4.3. Risk of Infrastructure Funds as Infrastructure Financing

The AHP analysis results for level 3 showed that the first financial risk where debtors' ability to return the loaned funds to finance infrastructure projects through the PPP scheme is a form of constraint for the implementation of insurance funds as the alternative source for infrastructure investment and the solution to address this should be sought by private sector assuming all the risk responsibilities. The second financial risk, the changes in the price level, is found to be a potential, whereas this price level change is a benefit for the investors from both the public and private sectors in establishing infrastructure financing.

Changes in interest rates as the third financial risk is a constraint; thus, the role of the government is very significant in determining the interest rate level for the insurance fund. The insurance investment portfolios, which are more interested in short-term investment, are also a constraint that should receive major attention from the private sector in order to make insurance fund an alternative financing source for infrastructure in Indonesia. The fifth financial risk is also considered a constraint; therefore, the government and private sector, in this case, insurance companies, should work together to find solutions for the obstacles caused by the changes in insurance industry assets (see Table 4).

Table 4 AHP Analysis Result (Level 3)

Variable	Insurance Funds' Infrastructure Investment Risks	Analysis Result		
		Level 1	Level 2	Level 3
Financial Risk				
X1	the debtors' ability to return loans	Constraint	PTE	AR
X2	changes in the price level	Potency	PTE	EDR
X3	changes in interest rate	Constraint	GOV	MR
X4	insurance investment portfolios are more into short-term investments	Constraint	PTE	AR
X5	changes in insurance industry assets	Constraint	PTE	EDR
Political Risk				
X6	unclear insurance regulations for infrastructure financing	Constraint	GOV	AR
X7	investment restrictions regulation	Constraint	GOV	EDR
X8	insurance fund more as an alternative financing	Potency	GOV	AR
X9	government policies that often change	Constraint	GOV	AR
X10	tax increase	Constraint	GOV	AR
Liquidity Risk				
X11	level of solvency and liquidity	Potency	GOV	AR
X12	project financing flexibility	Potency	GOV	AR
X13	lapse rate	Constraint	GOV	AR
Market Risk				
X14	Limited information on insurance investment in infrastructure projects	Constraint	PTE	AR
X15	economic growth	Potency	GOV	AR
X16	unfavorable investment climate	Constraint	GOV	EDR

Four of five variables in the political risks have appeared as constraints for insurance funds to finance infrastructure projects. To address the risk of unclear insurance regulations for infrastructure financing and investment, the government needs to implement clear policies that support insurance funds as alternative financing in infrastructure development so that the investors' participation can be increased; meanwhile, regulation on investment restrictions could hinder infrastructure financing by insurance fund, the government also needs to help remove investment restriction by making necessary policies. In addition to that, the government's role is required in order to distribute and socialize the concept of infrastructure financing by insurance fund to increase the private sector's interest as the insurance fund for infrastructure investment is found to be a potency. However, the government policies that often change together with the change of government leadership could inflict a loss for the investors while making investments in infrastructure financing, and it is the responsibility of the government to improve the implementation of policies that can bring benefit for all parties involved. As the tax increase isalso seeno to be a constraint, it is necessary for the government also to determine the tax value that doesn't burden the investors.

The level of solvency and liquidity comes out as potency that can be used as an alternative source through the PPP scheme between insurance companies and the governments as the decision maker for the solvency and liquidity level. Another potency of liquidity risk comes from the flexibility in project financing, where it is, in fact, expected by investors in financing infrastructure; therefore, the government's role as a regulator in providing ease of project financing for the insurance funds. However, the lapse rate determined by the government turns out to be a constraint for infrastructure financing using insurance funds.

From market risk, it is found that the limited information on insurance investment in infrastructure projects makes investors unaware of the benefits of financing infrastructure projects using insurance funds, so it is necessary for the government to have the information socialized well. Nevertheless, economic growth is a potency that is highly expected by the implementation of insurance funds as the financing for infrastructure development; it is the responsibility of the government to ensure the country's economic growth so that the market of insurance investment can be more promising. It is also the responsibility of the government to ensure that the investment climate for insurance investment is conducive, as it comes out as a constraint.

4.4. The Utilization of Insurance Funds as Infrastructure Financing in Indonesia

Several constraints appeared in the result of the AHP analysis, some of them that are prominent should get more attention from the insurers and the government in the realization of insurance fund utilization in infrastructure financing, here are some constraints that are more prominent than the others. Thus, these prominent constraints could be followed up by both the government and the private sector, which in this case is the insurance companies.

As can be seen in Figure 3, the insurance investment portfolios which are more interested in short-term investment is the constraint that has the biggest score among other constraints, where funds invested by the public and private sectors in insurance companies in Indonesia are reinvested in the form of bonds, shares, lands and building, deposits, mortgages, and Bank Indonesia Certificates (SBI). The Insurance industry's investment portfolio placed most of its investment in deposits and stocks, respectively, around 24% and 20.4% of the total insurance industry investment as of 2014 (Setianto, 2016).

Other constraints that also have high scores in the analysis include changes in insurance industry assets, government policies that often change, and limited information on insurance investment in infrastructure projects. The Government has made various efforts to deal with these constraints in order to get the infrastructure development program that has been planned to succeed, both in the form of improved regulations and the establishment of financial institutions and guarantees and finance. Even though the macro policy has been agreed to make investment conducive, in practice, infrastructure investment financed by private investment is still going slowly.

In addition to the analysis of the above constraints, several risks potential for utilizing insurance funds for infrastructure financing are also recognized. As can be seen in Figure 4, the most prominent potential among the potential risks is economic growth. Indonesia's economic growth has experienced quite rapid development. At the very least, the rate of economic growth, which reaches around 6-7% per year supported by the rapid financial services industry, especially insurance, has a very big influence on the growth of assets and investment in the insurance industry.

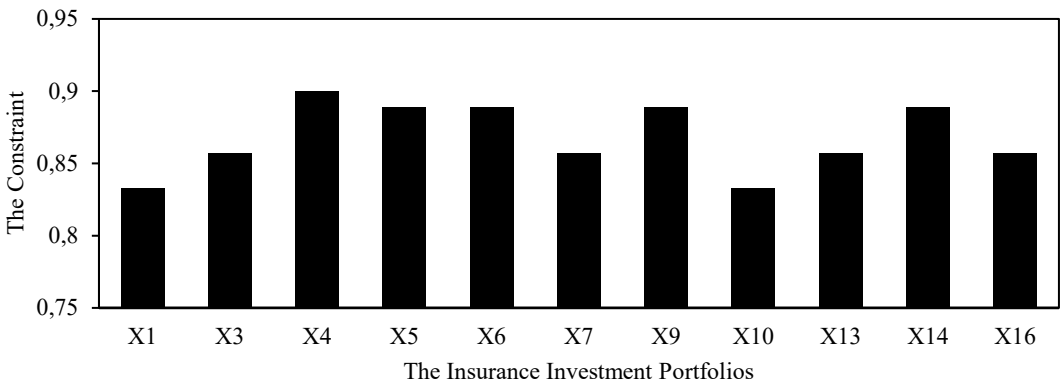

Figure 3 Analysis of the Constraints of the Insurance Fund for Infrastructure Financing

As the government plays an important role in regulating the investments for infrastructure development, therefore, this authority has the potential to improve the performance of infrastructure financing by providing guidelines for the insurance industry to invest its funds in infrastructure development. Besides, the accumulation of reserve funds has long-term characteristics so that it has a low liquidity level, so this has the potential for insurance funds to finance infrastructure that also has long-term investment characteristics.

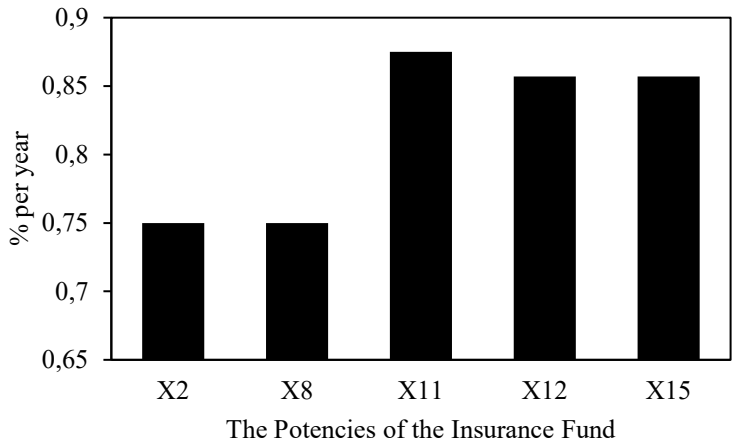

Figure 4 Analysis of the Potencies of the Insurance Fund for Infrastructure Financing

5. CONCLUSION

Infrastructure has a vital role in enhancing national economic development. Therefore, it is important to accelerate infrastructure development by opening opportunities for other financing sources to participate in its investment. Insurance funds have been widely discussed as alternative financing to be invested in infrastructure projects. Infrastructure is arguably an attractive portfolio investment for insurance companies as it is said to be more predictable and stable in terms of cash flow over long-term investments, as well as to be able to make diversification and reduce volatility.

The study conducted in this paper evaluates the constraints and potential for withdrawing insurance funds as an alternative source of financing for infrastructure investment in Indonesia. The subject of this research is alternative financing from non-bank financial institutions, namely insurance institutions, with research timeframes from insurance and investment industry asset

data. Insurance companies from 2006 to 2010 concluded that insurance funds are a potential alternative source of infrastructure financing in Indonesia. Therefore, despite already having clear and timely regulations regarding procedures for implementation of PPP in infrastructure provision established in the Regulation of the Minister of National Development Planning Number 2 of 2020, this paper encourages the government to open a solid pathway for insurance companies to take part in infrastructure investment by providing the specific requisite policies and legal aspects, as well as developing attractive partnership structures and models to attract private interest, especially insurance companies, to play an active role in the investment of infrastructure development.

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SHIFTING SUSTAINABLE MOBILITY AGENDAS IN GRAZ (AUSTRIA) AND HANGZHOU (CHINA): THE MULTI-LEVEL PROCESS FROM LIVABLE TO SMART CITIES

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ABSTRACT

Several studies on various urban sustainability projects have observed their conceptual and technological similarity worldwide but also identified significant divergences in their actual local framing and implementation. By analyzing sustainable mobility policies in Hangzhou (China) and Graz (Austria) and changes in their agendas during a period of thirty years, this article contributes to that discussion with new empirical insights. The development trajectories in Hangzhou and Graz will be compared to identify similarities and divergences and to suggest future paths for comparative studies in sustainable urban mobility. The study draws inspiration from multi-level governance theory and places the analysis within critical global urban studies.

Keywords: Austria; China; Low-carbon city; Smart city; Sustainable mobility

1. INTRODUCTION

Several studies on various urban sustainability projects have observed their conceptual and technological similarity worldwide but also identified significant divergences in their actual local framing and implementation. This paper aims to contribute to these comparative studies by increasing our understanding of policies that aim to achieve sustainable transition in different parts of the world. It analyses the multi-level governance of sustainable mobility policies in Hangzhou (China) and Graz (Austria) and the changes in their agendas from "livability" - traffic that does not deteriorate living conditions - to smart cities. This paper draws inspiration from multi-level governance theory (MLG) and places the analysis within critical global urban studies.

2. LITERATURE STUDY

Based on a survey of 178 eco-city initiatives worldwide, Simon Joss and his colleagues concluded that urban sustainability policies have become globally mainstream (Joss et al., 2013). Eco-cities in different parts of the world share global proliferation, international knowledge transfers, the centrality of "carbon discourse", and smart technologies. Although these initiatives share many common features, localizing the ubiquitous plans within each city's social, political, economic, and cultural context has led to great diversity between these eco-cities. The survey conducted by Joss and his research group exposed striking diversity in concepts, forms, and practices (Joss et al., 2013). More recently, Tomor et al. (2021) concluded that while smart urban governance initi-

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atives often appear identical, they diverge in their societal goals, collaboration, and use of technology based on context-specific factors. Overall, their study exposed a need to explore the institutional context of urban development projects, as it affects the entire development process from planning to implementation.

One specific aspect of the transition towards sustainability that deserves attention is fluctuations or reversals. As Hysing (2014) has observed in the case of Sweden, "green stars" in environmental policies can also fade. Leaders in green urban development may experience variations between policy areas and over time. For this reason, the assessment of the sustainability of any sustainability policy benefits from attention to a longer time.

A comparison between cities in a developed, democratic European country and in developing authoritarian China is fruitful for two main reasons. Firstly, despite their different developmental stages and political systems, Graz and Hangzhou are intensively engaged in promoting sustainable mobility, and they use largely the same concepts. It brings insights into the impact of the political system in the use of globally shared concepts. Secondly, scholars in several fields have called for more comparative studies between the "developed West "and the "developing South" to re-orientate Western-centered theory-building. (Roy, 2009; Robinson, 2011; Peck, 2015).

Because of this dichotomy, scholars have, according to Robinson, regarded cities in the developed and developing world as incommensurable. However, she maintains that because the "economic and social activities, as well as governance structures in different cities, are linked together through spatially extensive flows of various kinds and intense networks of communication", the cities share many similar experiences (Robinson, 2011). Leaning on her research, this article considers multi-level governance systems and their approach to sustainable mobility as comparable in their own right.

3. METHODS

The selection of Graz and Hangzhou as cases for this study is based on their record of ambitious sustainable traffic policies. They are both leading second-tier cities in their countries. They have launched similar city-branding strategies and are model cities in sustainable mobility development in their respective countries, which makes them comparable at the municipal policy level. While the cities are within the same "class" in their respective countries, their scales are not comparable. In 2020, the population of Graz was less than 350,000, while the permanent population in Hangzhou's administrative area was close to 12 million. They also differ in size. Graz covers an area of 130 km2, whereas Hangzhou spans an area close to 17,000 km2. It, without a doubt, creates differences in the scales of traffic flows and the magnitude of traffic-related issues between the two cities. For that reason, to keep the two cases commensurable, this study does not analyze the actual implementation of the policies. Instead, it focuses on the definition of the concepts and the selection of policy measures.

Multi-level governance (MLG) theory allows the examination of actors and impacting factors at several territorial levels. Initially, the concept was developed for the European Union and has served as both a concept of actual governance and an analytical tool. Later, it analyzed other regions and countries, including China. Ongaro et al. (2019) regarded the MLG framework as appropriate for the study of contemporary China because its governance system has transformed from a monolithic party-state into an authoritarian multi-actor network that is globally integrated, embodying essential objects for an MLG analysis.

Based on these considerations, this article explores: (1) how globally shared concepts were localized in Graz and Hangzhou, and (2) how do the various actors in the multi-level governance

system affect localization. Answers to these questions are expected to reveal interesting similarities and divergences concerning the localization of globally shared concepts for sustainable traffic between the two cities. This study does not aim at theory building but provides empirical evidence to help design more theoretically oriented studies in the future.

The study was conducted in two stages. Firstly, the conceptual framework was constructed during the inductive stage, guiding the collection and analysis of the materials during the deductive stage. The analysis is based on official documents from different levels of government in original languages. News reports and research articles have complemented and triangulated the official data.

This study traces the emergence of sustainable traffic policies from the end of the 1980s until 2020. This period covers the first initiatives to improve public transport, promote non-motorized mobility, and the subsequent waves of sustainable, low-carbon, and smart traffic policies. The year 2020 marks the end of one period in the case of both cities, so it fits well as the ending year of the period under scrutiny. The analysis of this timeframe enables the observation of shifts from one policy agenda to another and the changes in influential actors behind these shifts on various levels of governance.

In the following section, developments in Graz and Hangzhou will be described as narratives to highlight the local dynamics. In both cases, the trajectory can be divided into three phases: the emergence of the "livability" agenda, the shift to a low-carbon agenda, and finally, the launch of smart city initiatives. The discussion section will compare the MLG systems and development trajectories in Hangzhou and Graz to identify similarities and divergences and suggest future paths for studies in sustainable urban mobility.

4. RESULTS AND DISCUSSION

4.1. Graz: "Green Ebb and Flow"

4.1.1 A Multi-level Government System Emerges and Wanes (ca 1986-2000)

Erich Edeger, the strongman of the conservative People's Party in Graz, was a devoted cyclist. On his initiative, Graz started to create space for cycling lines and pedestrians in the historical city center in 1986 (Graz, 2015). Hence, contrary to the norm, the initiative for non-motorized mobility in Graz did not come from the green movement but from the conservative "car party." However, this policy certainly found support in the two Austrian green parties, which experienced an upswing in popularity in the mid-1980s.

An additional step towards environmentally friendly traffic practices occurred during the winter of 1988-89. After smog plagued the valley around Graz, the city was forced by the provincial government to take action to purify the air. Hence, in the late 1980s, efforts toward more sustainable traffic were also pushed forward by higher-level government units.

In the late 1980s, traffic prognosis predicted a rapid rise in motorized traffic in Graz, prompting city leaders to prepare the city for traffic development scenarios. Of the three potential plans, Graz's leaders selected the "soft mobility" vision that became the basis for the "Integrated Traffic Concept for Graz" in 1987. Since then, "soft mobility" has been Graz's guiding slogan for traffic policies. The "softness" refers to environmentally and socially sustainable means of mobility, such as cycling, walking, and public transportation. This alternative was expected to improve citizens' quality of life and make mobility smoother in the city. Guidelines towards this goal were passed in the city parliament in 1992, and they were developed within the framework of the

"Austrian Integrated Traffic Concept 1991" and the provincial equivalent. (Graz, 2015) These were Austria's first comprehensive traffic plans, and they aimed to promote environmentally friendly and non-motorized transport (Emberger, 2017). A strong emphasis on cycling encouraged Graz to claim the title of the Austrian capital of cycling (Graz, 2015).

In the early 1990s, the environmental initiatives in Graz were also linked to global developments and brand-making efforts. Graz had already joined the Climate Alliance for European Cities in 1991, and it was among the first European cities to implement Agenda 21 by issuing an Eco-city 2000 strategy in 1995 (Späth & Rohracher, 2011). As a result of the developments that had taken place since 1986, Graz emerged in its size class as a sustainable urban governance leader in Europe. The city was granted the Greenpeace Climate Action Award in 1993 and several other European awards during the following years.

Hence, a multi-level governance system on green mobility emerged during this first period in Graz. Local, regional, and global initiatives pushed forward actions toward sustainable mobility. City leaders actively collected European-level nominations to create an international green brand for the city. A comprehensive local network of enthusiastic civil servants, research institutes, and civil society groups was critical in the localization and implementation of the plans. (Späth & Rohracher, 2011)

However, local interest in developing sustainable modes of mobility waned over time in Graz. In general, there was decreasing public interest in environmental issues in Europe. (Späth & Rohracher, 2011). The shift was also visible in the national transport route plans that Austria published in the late 1990s, which emphasized economic development more than the environment (Emberger, 2017). The city government shifted its brand-building agenda toward culture and pursued nomination as a European Cultural Capital. Graz was awarded the title in 2003. The City Council did not prioritize the green agenda and sustainable mobility for a decade. In their study on the social dynamics of eco-city governance in Graz, Späth & Rohracher (2011) concluded that the lack of institutionalization of the local actor networks could explain the dilution of the green agenda. The transformation toward a more environmental and climate-friendly mobility system weakened when the networks disintegrated.

4.1.2 A More Comprehensive and Stronger Framework with EU Support (ca 2000-2010)

While environmental issues were sidelined in the City Council at the turn of the millennium, some actors in the city administration took new initiatives to promote low-carbon mobility. In particular, since the 2000 launch of the "European Climate Change Program" and the 2001 issuance of the "White Paper on European Transport Policy for 2010", several EU-funded projects served as frameworks for traffic-related governance actions in Graz.

Austria became an EU member in 1995 and actively began to participate in various EU programs for regional development and climate change mitigation. The first EU project in Graz that specifically focused on mobility was the CIVITAS Trendsetter, which ran from 2002 to 2006 and aimed to improve the availability and efficiency of public transport in Graz (Graz, 2020). Next, during 2005-2008, Graz participated in an EU-funded project called "Astute" to promote low-carbon traffic development. The project steered the administration's activities from infrastructure projects towards awareness-building to change the traffic behavior of city residents. Other outcomes included campaigns promoting non-motorized mobility, for example, through "car-free days" (Astute, 2009). These persistent efforts were awarded in 2008 when Graz was nominated as the Civitas City of the Year for its long-term commitment to "soft mobility" through a broad-portfolio sustainable transport policy. Due to the support from various EU-funded programs, the city could maintain its agenda of soft mobility despite waning political interest in low-carbon

mobility. The EU programs also increased the administration's awareness of environmental and climate-related issues, which likely created a more solid support network for low-carbon mobility. However, that cannot be confirmed with the materials used for this study.

Gradually, sustainable mobility returned to the political agenda of Graz when the Green Party gained more votes. In 2008, Lisa Rücker from the Green Party was appointed as a city councilor, with traffic, the environment, and commerce as areas of responsibility. Graz implemented several mobility-related surveys among residents and issued documents to give new life to the "soft mobility" policy. The most important of the documents was the "2020 Master Plan for Mobility" (Graz, 2010) which was built upon the provincial master plan from 2008 (Graz, 2021). In addition, Graz issued long-term visions until the year 2050. On Rücker's initiative, Graz also launched a bike pool experiment that started operating in 2012.

The shorter-term plan boldly stated that Graz would emerge as one of Europe's top 10 middle-sized cities and establish itself as an international smart city and center for innovation, technology, and smart services. (Graz, 2020) Graz also issued specific master plans for mobility, energy, and climate protection. The slogan of this long-term plan was "I live in Graz", and it envisioned that by 2050, Graz would have developed into a dynamic, affluent city with the highest quality of life. However, these plans seemed rather centrally driven and at the core of the outward brand-making efforts. For example, the slogan "I live in Graz" was not widely known among Graz residents (Unofficial Discussions in Graz, 2016). In any case, Graz aimed to reach these goals by enabling green mobility and reducing the necessity of using vehicles.

The leading idea of the master plan was that behavior change requires a change in one's way of thinking. The slogan of the awareness-raising campaigns was "Mobility starts in the head." This kind of change in thinking would also make soft mobility socially acceptable and attractive (Graz, 2010).

The plan further emphasized that the traffic department should not be the only unit that promotes and supports bicycling but also other actors, such as companies, schools, and public institutions (Graz, 2010). Hence, the local government decided to make concerted efforts to create a broad and institutionalized network of local actors supporting these policies.

As the new documents were prepared and issued, a new tide turned the public attention towards immigration issues, and right-wing populist ideas started to occupy the political agenda, taking attention away from environmental issues.

Despite fluctuations in the attitudes towards sustainable mobility during this period, various EU-funded projects supported the gradual institutionalization of green mobility governance practices in Graz. Once the public support for green transport strengthened again, the City Council took a strong role and issued decisive long-term plans leaning on the local "soft mobility" brand. These plans were incorporated into the new internationally-oriented city branding strategies that gradually laid the ground for comprehensive smart city plans.

Smart Infrastructure for Cars (ca 2010-2020)

A change in the relative strength of political parties in the City Council in 2012 led to compromises in the ambitious plans on "soft mobility." During the 2012 elections, the Green Party lost voters. Traffic became the responsibility area of Mario Eustacchio from the right-wing populistic Freedom Party of Austria. He criticized his predecessor's costly green traffic project and turned down a new cyclist and pedestrian-friendly projects that would have required significant investments (Radlobby Argus, 2013). According to a local researcher and green activist, the cycle-friendly political atmosphere had faded by 2016. (Discussions in 2016).

These developments occurred despite the 2011 EU White Paper on Transport and the subsequent Austrian Transport Master Plan of 2013, which introduced measurable reduction targets for emission and energy consumption. Nevertheless, the EU remained a central source of inspiration and funding for various mobility-related initiatives in Graz (Graz, 2020).

The master plans for mobility were still in effect, and the vision for a Smart Graz was a central component of the long-term plans that stretched until 2050. The smart city plan became the main component of the city's development and branding in 2013 (Nussmueller, 2017). The smart projects provided a suitable framework for pro-car politicians, as the focus could be shifted from various restrictions to car use to smart infrastructure projects. The smart city pilots were also anticipated to generate commercial solutions that could be replicated elsewhere in Austria and abroad. Hence local researchers and companies became central actors in the local traffic governance framework.

The visions that were related to mobility focused on the saving of resources (Graz, 2016a). Typical for smart city projects, many of the projects in Graz were limited to certain areas in which smart infrastructure development was more feasible and would create more added value (Graz, 2016b).

The global, EU-level, and national concerns for the impact of motorized traffic on climate change and the livability of cities were reframed during this period within the globally trending smart city agenda. It enabled the expansion of motorized traffic, which found wide support among the voters. In addition, it provided a suitable platform for city branding and the marketing of local smart city innovations. In this way, companies and researchers became closely involved in the local mobility-related governance network. Various EU-funded initiatives enabled the continuation of low-carbon "soft mobility" projects.

Looking at the outcomes of the policies, the modal split of mobility has not significantly changed since 1982. The share of car trips was 42.6% in 1982; some 40 years later, in 2018, it was only one percent lower, at 41.6%. Despite numerous efforts to improve the public transport network and its availability, the use of public transport had only increased by 1.7 %, to 19.8%. However, here, it needs to be noted that the population of Graz had grown by 50,000 residents during that period, and thus the number of public transport users was much higher in 2018 when compared with 1982. A significant development was the clear increase in cycling. The share of trips made by bicycle increased from 8.2% to 19.3% (Presse, 2021).

Table 1 Important Documents and Initiatives within the Multi-level Governance Framework: Graz

	Phase 1 (1986-ca 2000)	**Phase 2 (ca 2000-2010)**	**Phase 3 (ca 2010-2020)**
global	- Agenda 21 (1992) - Kyoto Protocol (1997)	- Copenhagen Climate Change Conference (2009)	- Paris Summit (2015)
regional	- EU projects	- European Climate Change Program 2000 - White Paper on European Transport Policy - EU projects	- EU White Paper on Transport (2011) - EU projects
national	- Austrian Integrated Traffic Concept (1991) - Austrian Federal Transport Route Plan (1998)	- Austrian Transport Master Plan (2002)	- Austrian Transport Master Plan (2013)

	Phase 1 (1986-ca 2000)	Phase 2 (ca 2000-2010)	Phase 3 (ca 2010-2020)
provincial	- Smog prevention (1989) - Styrian Integrated Traffic Concept (1991) - Styrian Integrated Traffic Concept (1991, 1996, 2000)	- Styrian Master Plan for Mobility 2008+ (2008)	
municipal	- Soft mobility initiatives (1986) - Integrated Traffic Concept for Graz (1987) - Transport Policy Guidelines 2000 (1992) - Eco-city 2000 (1995)	- 2020 Master Plan for Mobility (2010) - 2050 Smart city vision (2010)	- Smart City Graz (2013)

Note: The table is not meant to be exhaustive. It contains a selection of the most important policy documents.

4.2. Hangzhou: "Quality of Life without Travel Problems

4.2.1 Tackling the "Travel Problem" with National Pilot Projects (ca 1990-2005)

At the national level, from the 1980s until the early 2000s, China's traffic policies focused on expanding the road system. Private car ownership was new in China, and boosting China's car industry became gradually a national priority. Families were encouraged to buy cars (Wang & Chang, 2014). Only in 2004 did the Ministry of Construction issue guidelines on developing public traffic, initiating a series of national-level guiding documents on improving the urban public transport systems. It was not until 2007 that the State Council issued a document prioritizing public transport. The document "Comprehensive Energy Reduction Program" required cities to construct rapid public transport and metro lines to reduce energy consumption (Pan, 2012).

Despite a strong domestic agenda on traffic, global agendas were also visible in China's national policy documents. China localized Agenda 21 in 1994 in a white paper, "China's Population, Environment and Development in the 21st Century." Government units at different levels of administration were urged to pay attention to the White paper in drafting the ninth five-year plan (FYP) for the years 1996-2000.

As the capital of Zhejiang, one of the richest provinces in China, Hangzhou's leaders have excellent resources to show their capabilities and pave the way for their promotion. Thanks to its ambitious leaders, Hangzhou has been regarded as one of the best-managed cities in China. It has set emissions control indicators and evaluation targets that are the strictest in the country (Ahlers & Shen, 2018). However, during the 1990s, local city governments, Hangzhou included, were occupied with economic development while environmental issues were sidelined. Although the government of Hangzhou mentioned Agenda 21 in its ninth FYP (1996-2000), the available documents do not disclose to what extent the agenda was observed in local policy implementation.

The situation changed at the turn of the millennium. In 2000, the city government decided to tackle the most difficult problems the residents met daily. To this end, a city-wide survey was conducted. In 2002, based on additional surveys, solving the "seven urgent difficulties" became a slogan that Hangzhou leaders used to show their commitment to improving the city's livability. One of these problems was related to traffic, specifically, "traveling and parking." the city government identified solving the "travel problem" as its top priority. This was an urgent issue

in the city, as the number of cars had increased exponentially after China joined the WTO in 2001 (Ling, 2014).

Hangzhou applied to the "intelligent transport system" pilot cities project to support these mobility strategies and won the nomination in 2002. In 2004, Hangzhou published a localized version of the national public transport document emphasizing the role of public transport in solving the "travel problem". At the same time, Hangzhou was also profiled as a National Model City of Civilization and Culture, and public traffic policy was incorporated into that model city program. In this context, city authorities aimed to promote civilized and law-abiding traffic behavior among car drivers and cyclists. The campaigns also included awareness-building to guide residents to use public transport instead of private cars (Hangzhou, 2004).

The governance slogan of that time, "Government leads, policies support, society participates, markets operate" (Shi, 2002), illuminates the local governance network and the roles of different actors in developing the transport system. The local government had a central role in the planning and implementing the policies. However, in Hangzhou, leaders were willing to listen to the residents' opinions.

By the early 2000s, Hangzhou's mobility-related multi-level governance system showed strong dynamism between the city and the national government and its residents. Using the traditional local methods of socialist China of "collecting opinions from the masses", it identified traffic as one of the most urgent problems among residents. To solve these problems, Hangzhou actively utilized various pilot projects launched by the ministries. However, the residents were mainly concerned about traffic jams that complicated their daily lives rather than the environmental consequences of motorized vehicles to the environment. At the same time, Hangzhou could boost its profile as an exemplary city within China and show off the capabilities of its leaders, who were eager to get promoted to higher positions. Nonetheless, the international dimension of the mobility-related governance system remained rather weak.

4.2.2 Five-year Plan for a Low-carbon City with a High Quality of Life (ca 2005-2010)

After the turn of the millennium, Hangzhou and many other Chinese cities became a hot spot for various internationally oriented eco and low-carbon urban development projects. The frameworks of these projects were defined by international planning and architecture bureaus using the latest trendy concepts, and the cities became test sites for technological innovations. Hence, the low-carbon mobility features embedded in the globally circulating concepts of urban development also reached Hangzhou.

At the national level, the government responded to the UN framework convention on climate change by issuing the National Climate Change Program in 2007.

The 11th FYP (2006-2010) began a new cycle in Hangzhou's traffic policies. On the one hand, well-functioning traffic was linked to Hangzhou's new brand-building strategy. On the other hand, low-carbon economy, energy-saving actions, and carbon emission reduction were included in the national level plans and, hence, also localized in Hangzhou.

In Hangzhou, the framework for local actions was created by Hangzhou's new branding as a "city of quality life" which was declared in 2006 in Hangzhou's 11th FYP and later formulated into clear policy goals in 2007. The ultimate objective was to contribute to Hangzhou's branding as a livable city providing an excellent environment for residents and companies. The city leadership aimed to make Hangzhou one of China's most attractive cities and reach international recognition for its good living and business environment (Hangzhou, 2010; Delman, 2014). In 2010,

Hangzhou was designated as a national low-carbon pilot city, and low-carbon traffic was one important aspect of the pilot program.

Solving the major difficulties in people's daily lives was one of the core objectives of the "City with a high quality of Life" program. In 2007, the city issued a new document on how to solve the "seven urgent difficulties" experienced by the residents of Hangzhou. The policy document emphasized the improvement of the public traffic network but also included measures for improving traffic behavior. The document emphasized good manners, respect for traffic rules, and awareness about green mobility. The document promoted a "public traffic week" and "car-free day" with the slogan, "Green mobility starts with me" (Zhejiang News, 2009), which resembles Graz's slogan, "Mobility starts from the head."

In connection with Hangzhou's ambitions to become a low-carbon city, its leadership decided to improve the policy implementation system to ensure the goals would be met. While it is usual for city leaders to declare such goals, environmental issues during that period were typically still neglected in favor of economic growth. A central method in China to ensure the implementation of policies is the civil servant appraisal system, wherein civil servants in leading positions sign annual contracts that define a set of goals that they need to reach to receive bonuses and ensure promotions. In Hangzhou, properly considering residents' opinions became a central criterion of civil servant assessment.

To respond to the wishes of the city dwellers, the municipal authorities used various channels to collect people's opinions. These channels and methods included the regular arrangement of surveys, the opening of telephone hotlines, the organization of residents panels, the use of traditional "letters and visits" methods of individual complaints, the use of communist mass organizations to collect people's opinions, and the establishment a website through which residents could post complaints and wishes.

The most important of these methods was the aspect of social assessment, which counted for 65% of leaders' performance assessments at the sub-municipal level. Responses were collected from ordinary citizens through traditional surveys. The influential social organization "Green Hangzhou" was an expert evaluator, and opinions were collected from companies and business organizations. The first of these comprehensive surveys was conducted in 2011. The dual problem of road transport and car parking topped the surveys, together with air pollution from vehicles (Delman, 2019).

The "Comprehensive Energy Reduction Program" that the State Council issued in 2007 required cities to construct rapid public transport and metro lines. Hangzhou started the building of metro lines the same year. However, another public transport initiative that became a signature for Hangzhou was its bike pool. Hangzhou was the first city in China to build a public bike system, and by 2015, it had grown into the world's largest, with 84,000 bikes and close to 3,500 bike docking stations. (Hangzhou Daily, 2015). The building of the bike pool began in 2008 as a part of the attempts to develop a city with a high quality of life. The bike system complemented the development of the public transport system by solving the "problem of the last kilometer" from bus to work and home. Hangzhou received additional funding for the development of the bike pool from various Chinese pilot programs such as the Improvement of the Transit System pilot, National Bicycle Transit System pilot, Public Transport Metropolis pilot, and City of Green Transport pilot. The commercial Hangzhou Bicycle Service managed the system. The local government provided the initial infrastructure cost, and the company collected revenues from advertising. It started turning a profit in 2010. In 2017, the Hangzhou Bicycle Service won the British Ashden Award for Sustainable Transport, which brought international fame to the city.

2010 the city issued specific traffic-related guidelines that reconfirmed a public traffic system comprising five transport modes. A bicycle pool, taxi services, and ferry lines would complement

the public bus and subway system. Thanks to its efforts, Hangzhou was nominated as the Public Transport Capital of China in 2013, and the sustainability trend gained further momentum when Hangzhou was appointed as the National Green Traffic Pilot City in 2016. The 2010 guidelines also laid the ground for the wider informatization of the traffic system (Hangzhou, 2010). It paved the way for the comprehensive digitalization of the mobility management system in Hangzhou, which will be discussed in the next section.

While residents' concerns and wishes were considered, they were subdued when the interests of the city's growth coalition were at stake. For example, the new metro lines and stations were not located in the old suburban areas where they were most needed. The increase in the price of land in newly developing residential areas was of higher priority in the city government, which received hefty revenues from land leasing, and within construction companies, who profited from higher estate prices (Xue et al., 2011).

During this period, the global low-carbon agenda was localized in China in consequent steps from the national level to municipalities. Various national pilot projects strengthened Hangzhou's reputation as a low-carbon public transport capital of China. While the low-carbon framing was important for city branding, actions in favor of public and non-motorized traffic were increasingly taken in Hangzhou due to pressure from residents (Ahlers & Shen, 2018). City dwellers who, in the early 2000s, had complained about commuting problems gradually became more concerned about the environmental impacts of motorized traffic.

The influence of international climate programs became stronger in the multi-level traffic governance system, which also expanded horizontally in Hangzhou. On the one hand, residents and selected social organizations were listened to more carefully. Still, on the other hand, the corporate sector gained a strong position in developing new traffic lines.

4.2.3 Low-carbon City Brain with a Dense Multi-level Governance System (ca 2010-2020)

Hangzhou's first smart city plans were launched in the early 2010s when it declared itself "Smart Hangzhou". Hangzhou's 12th FYP (2011-2016) was built upon this new concept in tandem with the city's low-carbon strategy and "quality life" branding. Consequently, local traffic plans were framed within a low-carbon framework with a strong "smart" techno-agenda. The plans benefited strongly from the Chinese tech giant Alibaba, which had its headquarters in Hangzhou. One of the popular features of Hangzhou's smart traffic policies was its traffic app. The app, which at that time had 15 different functions, provided information about timetables and disturbances in traffic and allowed passengers to buy tickets, book a taxi and send traffic-related comments, complaints, and suggestions.

China's informatization strategy and, consequently, Hangzhou's smart city plans reached a new level in 2016 with the 13th FYP for 2016-2020. One of the plan's goals was to develop "Digital China." This plan was localized in Hangzhou with the upgraded slogan, "New-Style Smart Hangzhou", which replaced the "quality life" branding. Again, Hangzhou acted as a national pilot city for the "City Brain" platform. "City Brain," developed by Alibaba, aimed to improve urban management with the help of big data, cloud computing, and artificial intelligence. Initially, the goal was to find solutions to Hangzhou's ever-worsening traffic problems by using data from sensors on traffic lights and in traffic cameras (Caprotti & Liu, 2022). According to Hangzhou's webpage, thanks to the system, Hangzhou's position in the national "traffic jam ranking" dropped from 2nd to 35th place (Hangzhou, 2020). Nonetheless, this likely meant that the city still experienced heavy congestion.

The City Brain solution is intended to be replicable and, at this writing, has already been sold to several cities outside of China. Hangzhou also continued developing its five modes of transport,

putting emphasis on public transport and "slow mobility" (walking and cycling) to uphold its designation as the Public Traffic Capital of China (Hangzhou, 2016).

While the traffic monitoring system covered the entire urban center of the city, some districts were designated as specific areas of digital development, particularly when the City Brain 2.0 was launched in 2018. For example, Hangzhou's Xiaoshan district, which was selected to host some Asian Games competitions in 2022 (postponed to 2023), was refurbished with the latest digital technologies to showcase China's tech capabilities.

Alongside high-tech solutions to traffic-related problems, also purely regulatory measures were taken. In an air quality study conducted by Greenpeace, Hangzhou ranked 43rd out of 74 Chinese cities in 2014, which was not very flattering for a city that wanted to be known for its high-quality living environment. To tackle the issue, the provincial government issued strict restrictions on the use of cars and sales of car licenses in 2014. According to city officials, the amount of PM2.5 air pollution from traffic dropped from 40% in 2011 to 28% in 2014. Typical for China, these and other regulatory efforts towards better air quality were also taken in preparation for the 2016 G20 summit meeting in Hangzhou, by order of the Ministry of Environment, to convey a positive image of the city for the top-ranking visitors (Shen & Ahlers, 2019).

Caprotti & Liu (2022) have shown in their research that Hangzhou's digital urban platforms were planned by actors on multiple levels, from ministries to the provincial government to local authorities in different sectoral departments. The national-level plans for China's digitalization and Alibaba's presence provided exceptional conditions for the localization of smart city plans in Hangzhou. Digitalization and smart solutions penetrated all aspects of traffic management in Hangzhou, from steering traffic flows to soliciting feedback from residents.

From the early 2010s to 2020, the public transport system expanded significantly in Hangzhou, especially thanks to the metro system. In 2011, only 20% of daily commutes in the central districts were taken by bus. At that time, the first subway lines were just about to open, and a quick increase in the use of public transport was to be expected. The share of public traffic was expected to pass 50% by 2021 (Zhongxinwang, 2013). In 2020, the share of motorized public traffic was reported to be 52.4% (Hangzhou, 2021).

Table 2 Important Documents and Initiatives within the Multi-level Governance Framework Hangzhou

	Phase 1 (ca 1990s- 2005)	**Phase 2 (ca 2005-2010)**	**Phase 3 (ca 2010-2020)**
global	- Agenda 21 (1992) - Kyoto Protocol (1997)	- Copenhagen Climate Change Conference (2009)	- Paris Summit (2015)
regional	-	-	-
national	- White paper on "China's Population, Environment and Development in the 21st Century" (1994) - Opinions on Prioritizing the Development of Urban Public Transport (2004)	- National Climate Change Program (2007) - Comprehensive Energy Reduction Program (2007) - National pilot and model city programs	- Guiding Opinions on Prioritizing the Development of Public Transport in Cities (2012) - Atmospheric Pollution Prevention Action Plan (2013) - Ministry of Environmental Protection: G20Blue (2016)

	Phase 1 (ca 1990s- 2005)	Phase 2 (ca 2005-2010)	Phase 3 (ca 2010-2020)
			- National Informatisation Strategy 2016 –2020 - National pilot and model city programs
provincial	- Provincial equivalents of the national-level documents	- Provincial equivalents of the national-level documents	- Provincial equivalents of the national-level documents - Car license plate restrictions (2014)
municipal	- Measures to solve the seven urgent problems (2002-) - Constructing the "Urban Public Transport Priority" System and Solving the Problem of Citizens' Traveling Difficulty (Trial) (2004)	- City of Quality Life (2007) - Priority Development Strategy of Public Transport to Create "Quality Public Transport" (Hangzhou, 2010)	- Smart Hangzhou (2010) - New Style Smart Hangzhou (2016) - Hangzhou Climate Change Plan (2013-2020) - Hangzhou Air Pollution Prevention and Control Action Plan 2014—2017

Note: The table is not meant to be exhaustive. It contains a selection of the most important policy documents.

5. CONCLUSION

The following preliminary results can be obtained when looking at the dynamics of multi-level governance as they relate to sustainable mobility policies in Graz and Hangzhou.

On the surface, the emergence and strengthening of low-carbon and smart agendas can be explained by local growth coalitions that followed the globally spread neoliberal rationality of rebranding the city to compete for a higher position in the global hierarchy of cities. Similar agendas were used in both cities to brand them as globally competitive and attractive places for investments with high-quality living standards. Both cities also utilized smart city agendas for advertising and creating markets for their local technological innovations. However, these entrepreneurial urban sustainability strategies are planted in different soils and thus develop other characteristics. They follow their dynamics and create variegated outputs depending on the local coalitions that promote them and their socio-political context. Building on Parnell and Robinson, Lawhon & Truelove (2020) maintain that "even where neoliberalism is prevalent, its explanatory power is not ubiquitous, and at times the concept insufficiently explains the causality of urban outcomes". It is imperative to take a bottom-up view to expose other important causes for change.

In Graz and Hangzhou, the city level of governance was, as expected, the primary actor and the two cities were actively applying for important financial and strategic support from above. National policies created an important framework in both cities, and the provincial government occasionally intervened in their mobility-related issues. In the case of Graz, various EU funding schemes provided critical support and guidance, whereas Hangzhou benefited from various pilot city programs linked to China's development strategies. Both cities developed their own mobility concepts that steered the localization of global and national-level agendas.

Both cities communicated with residents to improve their traffic systems and raise awareness about the benefits of public and non-motorized traffic. Campaigns such as "car-free day" were arranged in both places. However, the differences in political systems created divergences in how citizens could affect local traffic planning. In Graz, residents could influence traffic strategies through elections and survey participation and by being active in NGOs and political parties. In Hangzhou, residents could air their opinions and wishes through different consultative channels, and the city government relied on the expertise and resources of local environmental and social organizations. As the assessment system of the leaders in Hangzhou was tied to public opinion, these channels directly impacted local traffic policies on some issues. Another difference between the two cities lies in the level of environmental awareness among the residents. In Graz, the Green Party supporters and environmental experts were pivotal in promoting the green traffic agenda from the 1980s onwards. In Hangzhou, residents who demanded improvements in the traffic system were initially not interested in environmental issues but in a less troublesome daily life. However, as air pollution became severe, it ranked as the top concern among residents in municipal surveys.

Once the smart agenda became prevalent, high-tech companies became more prominent in localizing sustainable mobility policies in the two cities.

The results of this study also remind us that the direction of traffic policies can change again. Stakeholders should prepare for the possibility that national or supranational leaders could begin to focus on priorities other than low-carbon traffic, that public opinion could shift, or that the city leadership could fall into disfavor with national leaders and channels of support could be cut. Moreover, an intensive focus on smart solutions could lead to the concentration of high-tech low-carbon life in privileged posh districts while leaving the rest of the city with declining public traffic and worsening traffic jams. Thus, determining how to ensure the sustainability of sustainable traffic policies should be a key objective for future comparative research. This study has provided empirical evidence of similarities and divergences in localizing sustainability concepts. However, more comprehensive studies are needed for theoretical development.

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PEOPLE-CENTRIC AND INCLUSIVE APPROACH TO PLANNING OF SMART CITIES

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ABSTRACT

The smart city continues from intelligent, creative, and sustainable urban development imaginaries and started as a technologically oriented urban development framework. Since its conception, debates between academics, planning practitioners, and private firms have expanded and questioned original notions of 'smart' to consider people-centeredness, participation, and inclusion themes broadly. These discussions in smart cities have pointed to a need to question and revise many of the aims, approaches, and methods related to smart urban development. This review asks what elements and factors could be required for a city to be considered smart and people centric. The participatory design enabled by digital tools, a holistic appreciation of place-specific complexities, and considerations of how different demographics can appropriate 'smartness' as part of their everyday lives could be considered as such factors. Alongside describing participatory design principles more broadly, this paper considers the case of aging and seniors as an example of a group often viewed as deviating from the "average" user. This demographic often does not benefit from smart city design approaches targeting the "average" city user. Furthermore, the paper considers the potential pitfalls of participatory approaches.

Keywords: Digital technology; Participation; Participatory design; People-centeredness; Smart city

1. INTRODUCTION

An increasing number of cities are striving to improve the quality of life of their residents, improve city governance, and increase economic activity and liveliness in their towns (Söderström et al., 2014; Anthopoulos, 2017). As a result, they have branded themselves as smart cities. The smart city is an urban development imagination that provides comprehensive future visions and guides current developments (Caprotti, 2019). It is a continuation of such urban notions as the creative, intelligent, wired, or ecological city (Hollands, 2008; Vanolo, 2013; Söderström et al., 2014) but often with different conceptual origins (Haupt, 2021). While there is still conceptual ambiguity, the novelty of smart cities has been suggested to lay in the potential of concepts of networked technology, such as the Internet of Things and its many applications (Cardullo & Kitchin, 2019). However, the smart city and its "smartness" should be defined as transcending networked technologies. Instead, a real smart city undertakes development from a social and political problem-solving perspective while using technology as a tool (Suopajärvi, 2018).

Participation and people-centric approaches have been suggested as keys to success in the cities' efforts to become smart. These notions highlight the human and user perspectives in technology-

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driven urban visions. They have garnered interest from academics, practitioners, and private firms aiming to promote the sustained relevance of their products and services (Sepasgozara, 2019). However, this research work has been somewhat fragmented, focusing on specific elements of people-centric smart urban development. This review attempts to synthesize important findings from this research work by continuing from these discussions.

Most importantly, it is asked how smart city development should be approached for it to be considered people-centric and what some main criteria of a people-centric smart city could be. It is done by exploring smart cities through discussions on people-centeredness, effective participation, and inclusion in the existing literature. A people-centered approach considers the needs of city users and the effects of solutions and urban development on them (Leikas, 2008; Ji et al., 2021). Effective participation is understood as a crucial element of a people-centered approach. Participation can be effective when citizens and other stakeholders successfully communicate their views, preferences, and opinions in two-way communication with planners. It guides the design of the products and services. Inclusion is understood as equitable participation of all relevant stakeholder groups and the practices ensuring this occurs. (Bouzguenda et al., 2019).

Any city could promote itself as a smart city without real involvement from the citizens. While many definitions exist in the research literature, there are few descriptions of how to become a smart city. Even fewer descriptions exist of the role of people-centric approaches in its development. Smart city development will positively impact residents, commercial actors, and the city overall. These can be achieving sustainable economic development, a higher quality of life, utilizing natural resources wisely, and new opportunities for effective urban governance and inclusion (Caragliu et al., 2011).

While there have been some efforts for standardization, there needs to be a more universally acknowledged definition of smart cities (Yigitcanlar et al., 2019). The existing definitions differ in their emphasis on different areas, such as community and community spirit, decision-making, technology, productivity, innovation, quality of life, well-being, sustainability, accessibility, governance, and urban development (Anthopoulos & Fitsilis, 2013). A popular alternative approach has been to conceptualize the smart city as concerning virtually all aspects of the city, where smart (technological) solutions to the economy, mobility, environment, people, living, and governance are provided (Giffinger et al., 2007; Vanolo, 2013). This classification can be useful, but as citizens are involved in all these areas, equipping people with the tools to be “smarter” should be considered for all these areas, not as separate.

2. LITERATURE STUDY

Despite the diversity of definitions, defining a smart city to guide local efforts is essential to identify and assess objectives as well as mechanisms of impact and its components. The formulated definitions, are often the following:

1. The direction and aim of (smart) urban development
2. The areas that are affected by transformation by “smartness”.
3. Mechanism(s) of how smart urban development objectives are achieved

Many definitions emphasize increasing productivity and technology (Anthopoulos & Fitsilis, 2013), but themes of people-centeredness or inclusiveness can be found only in some definitions. Indeed, there is a concern in the research literature that smart city projects focus exclusively on adding and intensifying the use of technology while neglecting their sociocultural effects (Foth, 2018; Effing & Groot, 2016; Ylipulli et al., 2013; Ogie, 2016). A definition by Caragliu et al.

(2011) combines technological development, inclusion, as well as ecologically and economically sustainable development:

> *"[A smart city is] a city that is smart when investments in human and social capital and traditional (transport) and modern (ICT) communication infrastructure fuel sustainable economic growth and a high quality of life, with a wise management of natural resources, through participatory governance".*

In practice, it is often unclear to the participating actors what the goal of smart city development is or how to achieve it. Smart city projects are often promoted without a commonly identified definition and objectives. The concept is also often used too ambiguously in urban development discourse (Van den Bergh & Viane, 2016). Therefore, a local manifestation of a smart city should consider adopting a definition that guides local projects, including participation.

The review first starts by exploring elements of people-centeredness in a smart city. After this, participatory design is presented as an important element in people-centeredness and the effort of cities to become smarter. The review then provides an overview of the role of new technological and traditional participatory methods in facilitating planning and interaction in a smart city. Next, potential pitfalls are explored based on existing case studies. To demonstrate the importance of the preferences of different user groups and how to avoid "average user thinking," the case of planning for aging and seniors are presented. Finally, the conclusion summarizes the findings.

2.1. People-Centeredness

The efficiency and success of a city depend on integrating both "hard" technical and "soft" sociocultural infrastructures. The latter can be understood as social capital (Caragliu et al., 2011). The world's leading cities enable atmospheres that can be used to develop a vibrant and sustainable city (Caragliu et al., 2011; Effing & Groot, 2016). Hard infrastructure investment, such as implementing smart grids, is insufficient to achieve a smarter city (Salim & Haque, 2015).

People-centric development requires national and municipal governments to look at smart city development through the eyes of the public. The public's needs and preferences, as opposed to an expert-exclusive approach, should also guide the development of services and solutions (Ji et al., 2021). Many companies and city governments undertaking smart city development have responded to criticisms of technocracy by labeling their smart city development projects as people-centric (Cardullo & Kitchin, 2019). In the research literature, smart cities are often roughly understood as technology-centric or people-centric (Brynskov et al., 2018; Van den Berg & Viane, 2016). In a people-centric smart city, solutions are primarily sought with sociocultural tools rather than only technological ones (Hollands, 2008). However, in a real-world setting, this distinction is often fuzzy or a local brand of a people-centric smart city superficial (Cardullo & Kitchin, 2019).

A people-centered approach to the smart city is an approach that puts user needs and discovers user requirements at the heart of the design process (Leikas, 2008; Ji et al., 2021). People-centeredness can mean different things in different contexts. For example, in e-government, people-centeredness can refer to centralizing services and transactions in one place so that citizens do not have to go to several places or ensure that information is reliable and easily accessible (Chen, 2010). People-centeredness means putting the convenience of administrative transactions at the heart of technical design.

The ease of use of information technology is also a part of people-centeredness. Foth (2018) argues that the design of urban technology and urban interaction should focus more on improving the capabilities of citizens rather than the usability of information technology. For example,

digital tools are designed as intuitive, easy to use, and with room for creativity. In that case, they can solve the already recognized problem and bring about more positive developments than initially anticipated. As such, citizens should not be treated as mere objects of design but as actors who can bring about positive change.

Cities aspiring to be smart cities have an increasing selection of technological smart city solutions to choose from. From this variety, they should choose solutions appropriate to the city's local cultural context (Paulos et al., 2008). For example, this cultural fit can be explored through workshops (Pouke et al., 2018). If a cultural fit is established, the task becomes to deploy the technology and facilitate its adoption by citizens (Sepasgozar et al., 2019). In this case, the value of people-centeredness to designers is to understand the citizens and develop technologies that are as well-received as possible. Each city has unique characteristics to which solutions must be tailored (Varela-Álvares et al., 2017; Salim & Haque, 2008). Furthermore, solutions must be fair and equitable for the citizens and parties they concern (Schuler, 2016).

2.2. Participatory Design

At its core, involving citizens in planning is rooted in the idea that effective participation is key to city inclusion, safety, resiliency, and ecological sustainability (Shamsuzzoha et al., 2021). Participation in smart city development can be implemented using the same principles as other participatory urban development activities. With smart cities, however, the problem has often been the outright neglect of participation due to the emphasis on large-scale ICT infrastructure procurement.

The principles of people- and user-centeredness can be implemented through participatory planning. *Participatory design* is a holistic design method that ensures the suitability of solutions for users in the design phase. Participation should involve as many stakeholders as possible. Relevant stakeholders are those affected by smart urban development and city services. In particular, end-users should be included and involved in the process (Leikas, 2008). Participation should occur at as many design stages as appropriate, preferably already at pre-planning (Foth, 2018). In some cases, however, involving users only at the design and testing stages may be appropriate (Kopeć et al., 2017).

Techniques for participation can include interviews with citizens, experts, and focus groups, usability, utility, and accessibility surveys, encouragement towards sharing feedback and comments, setting up support services, and defining service quality criteria planning and implementation (Jaeger & Bertot, 2010). Participation can be organized by interacting with representatives of stakeholder organizations (indirect participation) or by, inviting interested parties through various media, or by using an online survey (direct participation) (Münster, 2017). Direct participation has a higher risk of excluding or filtering out potential users and participants, but it may have a better chance of creating a sense of community through collaboration (Foth, 2010).

It has been suggested that transitioning from a linear process model of urban development to iterative participation is needed (Münster et al., 2017, Brynskov et al., 2018). A pre-design analysis, briefing, professional design, and execution characterize a linear process. The iterative design process, on the other hand, refines designs through user feedback or other participatory "bonus rounds". These can be used to further develop the outputs from earlier stages. Iteration is enabled by the involvement of end-users and stakeholders in as many phases as possible.

One case example of participatory planning is the Oulu City Library project, which aimed to develop new services for the library or to reimagine and present existing services in a new way. The result was a virtual library that presented library material in a new way. In addition to the

library users themselves, the process involved researchers, city officials, and library staff. (Pouke et al., 2018).

The process started with initial interviews and meetings with library staff, followed by two workshops with participation from all stakeholders. Collaboration in the workshop focused on formulating ideas about the new services and how the library could be experienced in a new way. In the second workshop, the prototype was further developed. The process was considered participatory and iterative by the researchers and participants. It ensured that participants were able to re-evaluate the plans to maximize relevance. A decisive element to a successful final product is iterative design, where different stages of the product are evaluated using feedback or direct involvement (Pouke et al., 2018).

Participation can be about providing toolkits for citizens and users. This can mean enabling creativity to create new technological devices, providing tools for dialogue on the directions of the smart local city, or participating in collecting data for urban development through smartphones and other sensors (Brynskov et al., 2018). A combination of qualitative and quantitative data often provides the best insight (see, e.g., Dembski et al., 2020). A clear distinction must be made between voluntary and automatic data collection (Ogie, 2016). Data collection only constitutes participation when done knowingly by users. Furthermore, sensor data cannot be used to interpret the meanings people attach to their actions or substitute for experiential data.

A well-organized participation approach can tap into the latent skills of citizens and pool their efforts (Paulos et al., 2008). It is often called crowdsourcing: breaking down a large task or problem and encouraging people to solve it, for example, using various participatory applications (Simonofski et al., 2017).

Participation is useful because it enables accessing local knowledge to support research and urban development that goes beyond formal knowledge. This local knowledge consists of unwritten rules, stories, and ways of understanding in which citizens make sense of their city. In the participatory design process, the role of this knowledge is to refine expert knowledge by enabling perspectives that urban developers would otherwise be unable to consider. For example, it draws attention to how the designed solutions affect citizens. It also provides an opportunity to find cheaper solutions rather than onlying on extensive investment. Importantly, it highlights the unequal position of local communities in terms of resource provision (Paulos et al., 2008) and how smart urban development may contribute to it.

Trust between the administration and the citizens is paramount for local knowledge to be utilized and applied. The administration must have confidence in the potential of participation and trust in a functioning culture of civic participation. On the other hand, citizens need to trust the administration's sincerity in promoting goals of the common good and make use of local knowledge. Using local knowledge and communicating its role gives citizens more confidence in smart city development.

3. METHODS

Citizen-ability refers to the ability of citizens to improve their city or tackle its problems (Foth, 2018). To harness the skill of citizens, various participatory tools such as workshops, hackathons, maker spaces, living laboratories, or participatory geographic information systems have been introduced with which to enable and involve citizens. As the effectiveness and reach of only using traditional methods have been questioned, the available participation toolkit for planning smart cities involves methods of digital citizen participation (Bouzguenda et al., 2019) alongside traditional methods.

While combining different methods is highly recommended, each method is best suited for a specific purpose. Workshops are interactive face-to-face participatory tools and are effective because they enable more personal, higher level, and deeper interaction and non-verbal communication (Münster, 2017). Workshops are appropriate if they are organized to involve end-users and relevant stakeholders (Pouke et al., 2018). Hackathons are one form of a workshop. They are intense, semi-competitive events where the most concise possible briefing or problem statement is given to develop a new solution. The briefing and problem are defined by an external party, not the participants themselves (Cardullo & Kitchin, 2019).

Living laboratories (living labs) are platforms for experimentation in a real-world setting, for example, in the home or a specific part of the city. In living labs, the interaction between users and technology can be observed, and the observations can be used to develop new and useful products and services (Van den Bergh & Viane, 2016; Kopeć et al., 2017). At their best, living labs provide a holistic understanding of what works and what does not about a product or service. Users or policymakers may negatively receive living laboratories if city residents cannot participate in designing these products and services. The experiments may also be politically sensitive (Fredericks & Foth, 2013). For the development of smart and sustainable cities to succeed, pilots need to scale and expand from singular experiments to integrate with everyday practices (Van den Bergh & Viane, 2016; Brynskov et al., 2018).

Makerspaces are dedicated spaces that support ideation through peer learning, learning by doing, and technically oriented activities. They are intended as forms of longer-term participatory creativity. They provide tools and support for developing digital solutions if they are designed to focus exclusively on digital innovation. Makerspaces offer the possibility to form ideas without the need for deep and broad expertise (Caldwell & Foth, 2014). Expertise can also be provided by the organizers of maker spaces (Brynskov et al., 2018). However, the threshold for participation can often be quite high, and these spaces may therefore exclude many groups of city users. Therefore, they are more likely to only serve active citizens.

Information and communication technologies enable participation remotely and by a wider audience (Münster, 2017). In Iceland, promising results have been obtained on the performance of an online platform for urban participation (Effing & Groot, 2016). The Betri Reykjavik platform allows citizens to submit improvement and development proposals to the local government and other users to voice either support or disagree with the proposals. The platform collects open feedback and showcases proposals already implemented to encourage further input by citizens. From the perspectives of people-centredness and participation in a smart city, these kinds of services enhance the smartness of a city.

Participatory Geographic Information Systems (PGIS) allow citizens to obtain real-time, place-based information, provide location-based feedback and participate in planning specific places and areas with urban developers (Foth et al., 2018; Münster et al., 2017). These services should be easy to use and accessible. They require knowledge of how to use computers and mobile devices. PGIS applications and services enable new experiences of space and distances and facilitate a new perspective on development needs (e.g., Dembski et al., 2020). Participants communicate their feedback by commenting on city objects, drawing, modifying parts of a 3D model, or giving comments to planners or other city residents (Dembski et al., 2020; Münster et al., 2017; Kopeć et al., 2017). Spatial information applications can also be used to support land use planning (Brown et al., 2018).

The *Täsä* app, piloted in 2015, is a case example of a participatory app where users can report problems, suggest new ideas, communicate opinions, and answer surveys in Turku, Finland (Adenskog et al., 2017). Such apps could serve as the city's place-based social media (Foth,

2010). However, participatory apps must be reliable to gather an active audience (Adenskog et al., 2017).

Young people often prefer technology to integrate with their daily routines, preferably invisibly (Ylipulli et al., 2013). Gamification has been developed to reach and engage young people (Santti et al., 2020). Integration and gamification may work if the applications used contain elements that are familiar to young people. Gamification can enable a new perspective on spaces and places when integrated into everyday practices. It can attract new participants and engage them longer-term through rewards, but it needs to be done right (Münster et al., 2017). In the case of the Täsä app, feedback illustrated that elements of gamification on the app were missed by many citizens (Adenskog et al., 2017).

A collaborative culture of doing things together can be enabled through place-based collaborative applications. Online-based community networking services can potentially promote local community interaction (Foth, 2010). Place-based community networking services allow residents to manage their local social networks alongside other digital and non-digital means of communication. Such a community communication service works when it combines global communication services with place-based communication.

For digitally-enabled place-based community services to work, users need to be able to find each other voluntarily and spontaneously. These services work best for existing communities. (Foth, 2010). A communal spirit can be built by matching common interests, skills, activities, and existing networks. It can be organized either through an existing digital platform model for communication or, alternatively, local communities can develop their owmmunication platforms. Ultimately, place-based community communication services provide a way for voicing and identifying community needs.

4. RESULTS AND DISCUSSION

4.1. Challenges and Pitfalls of Participation

A recurring participation problem is that, in most cases, only the most active citizens are involved in the planning process (Kahilainen & Kyttä, 2006). For participatory smart urbanism, in addition to personal characteristics, sociodemographic factors such as occupation, gender, age, and ethnicity influence technology access and use. The concept of the digital divide is used to refer to unequal access to the internet, devices, and software and the resources to maintain them. Increasingly, there are also major differences in motivation, skills, and habitual patterns of technology use. (van Deursen & van Dijk, 2014, 2019; Ertiö & Ruoppila, 2014). Bridging these gaps as part of smart city development will broaden the user base for different smart city technologies.

Institutional factors may inhibit participation processes from the perspectives of planners, officials, and citizens. For planners and city officials, resources, flexibility in time and place, non-hierarchical power relations, or supporting informal social structures and interactions may be constrained by the rigidity of established planning institutions. This may lead to superficial citizen "engagement theatre" that serves only to look good on the outside (Kamols et al., 2021). From the citizen's perspective, while clear to planners, rigid urban planning processes may be difficult to understand, approach and follow (Halttunen et al., 2010). Drafting appropriate documents requires expertise, and these documents can be inaccessible to citizens (Staffans, 2004). This makes it difficult to understand participatory political processes.

Furthermore, only some have the time or expertise to contribute (Jaeger & Bertot, 2010; Halttunen et al., 2010). The problem of lack of time applies particularly to face-to-face interaction. People aged 18 to 45 may be busy and more mobile between cities. Therefore, they

may need more time to be able or willing to commit to imagining the future of their neighborhood in a participatory process (Fredericks & Foth, 2013).

Digital participation platforms or even social media can complement face-to-face participation, reduce the friction of distance, and encourage participation (Halttunen et al., 2010; Fredericks & Foth, 2013). They offer cities the opportunity to reshape relationships with their citizens. This means that participation through mobile devices is largely desired by citizens. For example, in the case of the *Täsä* app, citizens understood the potential of the app and hoped for more mobile participation (Adenskog et al., 2017).

Social media as a tool has been criticized for fostering superficial communication between and within stakeholder groups and for having little value to urban developers. However, social media can increase participation in face-to-face events by reaching many who do not or cannot find out about such events through other channels. (Fredericks & Foth, 2013). Indeed, social media may often be more suitable for informing citizens and stakeholder groups than effective interactive participation. These tools are needed as attempts to involve people often need to reach enough people, especially in public sector projects. This may be due to a lack of information, time, understanding, or accessibility. They also often reach only some user groups. The participatory process is self-selective and attracts active citizens, which means that the information may not represent the views of the relevant stakeholders as some groups may be completely absent from the data (Kahilainen & Kyttä, 2006; Münster, 2017).

Citizens interpret the planning process from their perspective, which may result in planners and participants talking past each other (Münster, 2017). This is problematic, as garnering local knowledge in these processes is essential to participative planning. The balance between local experience and expert knowledge needs to be reconciled with the objectives of smart city development. What are the participants' expertise limits, and when is it justified to prioritize knowledge from officials and experts?

The participation process itself may be flawed. If there is a lack of transparency or fairness, the outcome may be worse than the initial starting point. This can be considered with sufficient resources and care for the process itself. Practical case examples illustrate potential problems for participative processes. In Ghent, Belgium, the problem was maintaining stakeholders' involvement in the smart city project. Although the city's smart city strategy included a clause about putting smart citizens at the center of decision-making, it was difficult to realize this clause in practice.

Moreover, smart city initiatives often remained experimental and could not scale (Van den Bergh & Viane, 2016). In Dublin, Ireland, the focus of smart city development has been too much on corporate interests and consumerism, despite the ideal of people-centeredness, according to researchers. (Cardullo & Kitchin, 2019). This has led to flawed pseudo-participation. Consultation with citizens only took place after the objectives of the projects had already been decided.

In a municipal smart city project in Sarpsborg, Norway, it was difficult to maintain a relevant conversation on social media and keep it on track. In addition, participation did not reach a wide enough audience, and city representatives felt the knowledge collected needed to improve (Berntzen & Johannessen, 2016). In Oulu, Finland, seniors, and young people considered interactive smart displays and the content they provided irrelevant. Furthermore, seniors' lack of digital competence was a barrier to technology-mediated interaction with the city, and they did not know how to use the city's Wi-Fi network (Suopajärvi, 2015). The smart displays did not provide content of enough substance or relevance, even though the citizens had been asked in advance what kind of content they wanted. (Ylipulli et al., 2013). Upon asking, citizens do not always know what they want. In some cases, this points to the need for expert design knowledge.

An equally important argument can be made for even deeper participation: had citizens already been involved at the pre-planning stage, the city displays might not have advanced to the implementation phase due to their lack of added value, and resources would have been diverted elsewhere. Furthermore, technology development and deployment are difficult because laboratory conditions often differ from use and need in a real-world setting (Salim & Haque, 2015). Overall, the case example of Oulu illustrates the importance of early participation and an iterative design process.

Participation requires interaction rather than one-way communication. Urban displays or bedazzling visualizations of the future will not be truly inclusive without interaction between planners and citizens. (Ylipulli et al., 2013; Foth et al., 2018; Münster, 2017).

4.2. The Ageing and Seniors in the Smart City

A major pitfall is ignoring different target groups' various needs and preferences. The impact of resources and sociodemographic characteristics such as gender, age, and ethnicity on the opportunities to participate in the smart city is an important factor (van Deursen & van Dijk, 2014, 2019). Efforts to include and involve a wide user base must be sensitive to the reduced capacity of young people, linguistic minorities, immigrants, or marginalized people to participate. Seniors are, in many countries, a growing demographic whose participation often involves issues of reduced or lacking IT competence. Here, seniors and the aging as a user group for a smart city are considered fruitful because it challenges the notion of an average user and forces planners to consider group-specific needs. Therefore, this paper will examine the impact of aging on smart city participation.

For city officials, seniors and older people are often perceived as a homogenous group, predominantly needing protection and security and with little interest in wider social issues. They are often seen as reluctant to adopt new technologies (Suopajärvi, 2017, 2016). Smart city development enables some practices at the everyday level and may exclude others (Suopajärvi, 2018, 2017). With the introduction of digital systems, interfaces, and e-services, face-to-face transactions have already become more difficult or even impossible (Leikas, 2008). Running "offline" errands may seem the most practical way for seniors and going online may be difficult. Seniors may find it difficult to find the information they need from e-services. The lack of continuity as a theme in the discussions on smart cities is also often a concern for senior citizens (Suopajärvi, 2018). Therefore, planning should also be in service of the experience of citizens that not all that is familiar and dependable will be displaced. One option is to incorporate familiar elements into the designs of new technical solutions (Suopajärvi, 2015) and – following the notion of supporting citizen-ability – to invest in the IT skills of seniors (Kopeć et al., 2017; Foth, 2018). However, the typical set of IT skills of seniors will likely broaden and improve over time.

Consideration should be given to how different urban social groups, including seniors, can incorporate smartness into their daily lives rather than merely adapting to it (Suopajärvi, 2018). Without participation, urban developers' own experiences of the elderly are the only sources of information to draw on when other information is not available (Suopajärvi, 2017). So the needs of seniors may be seen as uniform. However, it is important to recognize differences between senior groups at the planning stage, for example, in terms of physical and mental condition and health. Workshops and usability studies can highlight the needs of different types of seniors.

The needs of the elderly include compensating for impaired sensory functions, alleviating problems caused by memory impairment, alleviating motor problems of the body, the need for support in installing software and hardware, and the need for analog and easy-to-use operating logic (Leikas, 2017). These needs concern seniors differently concerning differing physical and

mental conditions (Suopajärvi, 2015). In addition, seniors need human contact to support their use of information technology (Kopeć et al., 2017).

A key question in the involvement of senior citizens is what role senior citizens should play in smart city projects. As a rule of thumb, seniors are themselves best suited to answering most questions concerning them (Suopajärvi, 2018; Kopeć et al., 2017). The role of the elderly should be adjusted concerning the objectives of the local smart city development. Is the goal to build a 'technologically smart' smart city independent of its inhabitants, or will it emerge as smart only when senior citizens succeed in facilitating their daily lives through smart solutions? For example, the question is of central relevance to developing social and health services.

Smart city planning should consider whether it will benefit the elderly or instead make their daily lives more difficult and how participation to answer these questions is best organized. Efforts should also be made to predict the unintended consequences of smart city solutions and to identify alternatives to solving urban problems. The experience of self-efficacy concerning IT capability is a major determinant of willingness to use smart city technologies. This experience is influenced by each person's work experience, education, income, gender, place of residence, health, and potential disabilities. It is also shaped by the support from family and personal social networks to use technology. (Leikas, 2008).

Older people are interested in technology when it carries perceived benefits (Suopajärvi, 2015). However, even when perceived benefits are recognized, some aging seniors might refrain from using these services due to concerns about trustworthiness, privacy invasions, and personal information security (Suopajärvi, 2015). For many, direct or indirect positive experiences and increasing IT skills will help to alleviate their fears about changes brought by smart city development. (Leikas, 2008). Teaching technological literacy and experiencing one's role as part of meaningful urban development contributes to the participation of seniors (Kopeć et al., 2017).

5. CONCLUSION

Smart cities are part of a continuum of urban imaginaries and have grown in popularity since the mid-1990s. For long, the concept has been technology-oriented and often continues to be so. Since the 2010s, they have taken on a broader set of meanings beyond mere ICT infrastructure, including people-centeredness, inclusion, resource efficiency, and themes of ecological sustainability.

This review has attempted to capture central notions from these discussions by asking what elements and factors could be required for a city to be considered smart and people-centric. It is suggested that the principles of participatory design utilizing digital tools, a holistic appreciation of place-specific complexities, and considerations of how different demographics and appropriate 'smartness' as part of their everyday lives could be considered as such factors. In light of research in this field, smart city development can achieve its objectives if projects consider citizens' needs and daily practices, not just the solutions offered by equipment suppliers. Municipalities should also consider these when coordinating interaction and contributions among stakeholders. These considerations are rooted in the idea that effective participation is the key to inclusion, safety, resiliency, and even promoting ecological sustainability in cities (Shamsuzzoha et al., 2021).

Having clear ambitions for smart city development is important. A city aspiring to become a smart city should negotiate and communicate its objectives and means to achieve those objectives to stakeholders and citizens. One way to do this is to introduce a commonly recognized local definition of a smart city. Smart city development should be people-centric. People-centeredness means defining and placing user needs and requirements at the heart of the design process to achieve a socially, culturally, and economically sustainable smart city. Participatory, iterative

design can help to create a culture of collaboration in cities, which will help citizens to embrace the smart city. Smart city development should assume that end-users, whether young people, the aging and elderly, or immigrants, can identify their needs and provide insights that will contribute significantly to the refinement of appropriate solutions. This should be reflected in the participatory processes of authorities developing smart cities.

The success of efforts towards building a people-centric smart city could be measured with multiple indicators. As many elements associated with building soft infrastructures are qualitative, studies mapping inclusion through experiences by different user groups could be employed. Measuring the success and relevance of each participatory process to participants may be integrated into the process itself. Potential quantitative indicators could include participation and satisfaction rates or measuring funding directed toward participation. Combining quantitative and qualitative data is often the best approach to measurement.

True participation is also involved in the pre-planning phase, where participants "get to steer the ship, not just rearrange the deck chairs" (Cardullo & Kitchin, 2019). Smart city development policy should evaluate whether this is sufficiently enabled or whether participation should be expanded. This avoids experiments that are irrelevant to users, as the case of Oulu illustrates (Ylipulli et al., 2013). However, participatory design should involve stakeholders other than end-users, such as businesses, government officials, academics, and educational institutions. Without mutual trust between stakeholders, participation will not work. Citizens need to trust the interest of city officials and the government in collecting and using local knowledge and communicating its role in local decision-making. Contrariwise, governments must place trust in the usefulness of citizen participation for smart city development.

Information and communication technologies enable reaching groups not participating in "traditional" participatory events. Using social media is an effective way to inform citizens about opportunities for participation. Participation platforms such as the spatial data app Täsä in Turku, Finland (Adenskog et al., 2017) or Betri Reykjavik in Reykjavik (Effing & Groot, 2016), Iceland allow citizens to make their voices heard and offer perspectives that urban developers may not be able to consider. For the citizens, participatory technological applications can give them a new perspective on their city and its development potential. For urban developers, they are an opportunity to gain experience alongside expert knowledge for more solutions that stand the test of time and to learn about more inexpensive local solutions (Paulos et al., 2008).

The digital divide is defined as the resource gap in available devices, motivation, IT skills, and patterns of technology use. It affects target groups that can be challenging from the perspective of smart city development, such as senior citizens, linguistic minorities, and migrants. Bridging the digital divide in these four areas should be one of the objectives of smart city development. Measuring these gaps provides an indicator of the potential of citizens to participate. For senior citizens, the challenge is information technology and computer literacy and following motivational challenges. Seniors can be involved in workshops like any other citizen group but guiding and preparing them to maximize their participation is useful. Participation motivates seniors, and traditional involvement allows for the kind of face-to-face interaction that people appreciate. It is important that smart city development not transform everything but also continues to enable existing practices. Otherwise, seniors may feel that the projects are not for them. Usability studies are one way to check the usefulness of technology.

Future studies could research how people-centric approaches can be integrated and improved at the policy level. By investing in inclusion and people-centredness, cities have the potential to achieve significant efficiency and image gains in smart city development. Doing it right will ensure that the smart city concept can be more than just a catchword. Investing in cooperation and trust between stakeholders and gathering citizens' views and suggestions, new information

technology solutions can ensure that implemented smart solutions are equitable, fair, and sustainable. Bold initiative and institutional recognition of the value of participation are needed to take stakeholder cooperation to a new level.

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EFFECTIVENESS OF INTEGRATED TRAFFIC MANAGEMENT OF MILITARY POLICE AND TRAFFIC POLICE IN REDUCING DRIVE SPEED ON ARTERIAL ROADS: AN EXPERIMENTAL STUDY

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ABSTRACT

The Indonesian National Police Traffic Corps (KORLANTAS POLRI) and Indonesian Army Command and General Staff College (SESKOAD) in 2023 have conducted a joint study to reduce the number of traffic accident victims by implementing traffic regulations by the Military Police and Traffic Police. One of the methods used by KORLANTAS POLRI is the installation of Electronic Traffic Law Enforcement (ETLE) speed cameras on Jakarta toll roads, such as Cikampek, Jagorawi, Bitung, and others. At the end of 2022, 75 additional speed cameras were installed on arterial roads in Jakarta. This study aims to analyze the effectiveness of traffic regulations by the Military Police and Traffic Police in reducing vehicle speed. Data was collected by comparing vehicle speeds before, during, and after passing through the control zone. Data analysis was conducted using N Gain Score and normal distribution statistical tests with a 5% error rate. The study's results showed that the slowdown in vehicle speed through traffic regulation by the Military Police and Traffic Police could reduce speed by 43.76%. Over 95% of road users comply with speed limits when passing through the control zone. Thus, it can be concluded that implementing traffic regulations by the Military Police and Traffic Police has met the planning objectives in reducing the number of traffic accident victims. This method has proven effective in reducing vehicle speed and increasing road user awareness of complying with speed limits. In addition to installing speed cameras, traffic regulation carried out by Military Police and Traffic Police officers can be an effective alternative in reducing the number of traffic accidents on the road. This study shows that the collaboration between KORLANTAS POLRI and SESKOAD can provide important insights into traffic safety issues in Indonesia. Implementing traffic regulations by Military Police and Traffic Police officers can reduce traffic accidents and save lives. Modern technology, such as speed cameras, is important in this effort. It is recommended that this study's findings be shared with other law enforcement agencies to promote greater cooperation in improving traffic safety nationwide. Public education campaigns should also raise awareness among road users about adhering to traffic rules and regulations.

Keywords: Effectiveness; Speed management; Technology transportation system; Security system

1. INTRODUCTION

Traffic management is the road's management and regulation of traffic flow to achieve safety, efficiency, and comfort for road users and ensure good mobility. Traffic management covers various aspects such as planning, design, operation, maintenance, evaluation, and improvement of transportation systems. Several steps are involved in traffic management, including data collection and analysis, planning and design, traffic regulation, maintenance and repair, and evaluation and improvement of transportation systems.

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Ensuring optimal traffic safety and efficiency is important to implement traffic management, thus helping reduce road accidents and traffic congestion. Therefore, traffic intervention refers to actions taken to improve or optimize traffic flow. These interventions can be carried out using techniques such as traffic lights, vehicle sensors, or through manual regulation by traffic officers. The goal is to optimize traffic flow, minimize congestion, improve traffic efficiency and safety, and ensure good mobility for road users. One example of traffic intervention is manual regulation by traffic police. A study conducted by Sam (2022) indicates that traffic police are very important in a successful road safety strategy. Available literature identifies both traditional and automated traffic enforcement. In Ghana, traditional traffic enforcement involving visible police officers enforcing traffic rules and roadway regulations is employed.

Traffic accidents in Indonesia have become a serious and increasing problem recently. Data from the Central Statistics Agency (BPS) shows that there were 332,019 cases of traffic accidents throughout Indonesia, resulting in 26,948 fatalities and 29,297 serious injuries. One of the main causes of these accidents is high driving speeds, especially on arterial roads. Therefore, appropriate and sustainable actions are needed to address this issue.

In Tangerang Selatan city, high traffic density has made several arterial roads accident-prone areas, such as Boulevard BSD, Raya Serpong, and Graha Raya Bintaro. High driving speeds are one of the main causes of traffic accidents on these arterial roads.

Currently, the Indonesian National Police, in collaboration with the Indonesian Army Command and General Staff College (SESKOAD), is conducting research to address the issue of speeding on arterial roads, one of which is the integration of traffic control between the Military Police and Traffic Police. This integration is expected to improve coordination between the two security forces and help reduce speeding on arterial roads. However, the effectiveness of this program in addressing the issue of speeding and traffic safety on arterial roads in the city of South Tangerang has yet to be fully revealed.

Therefore, this study aims to identify and evaluate the effectiveness of integrating traffic control between the Military Police and Traffic Police in reducing speeding on arterial roads in South Tangerang. This study will analyze the factors influencing the program's effectiveness, such as vehicle types, time, and location. Additionally, the results of this study are expected to provide useful information and recommendations for the government and security forces in improving traffic safety and user comfort on the roads in South Tangerang. References from the Central Statistics Agency and the Ministry of Transportation show many traffic accidents and accident-prone areas on arterial roads such as Boulevard BSD, Raya Serpong, and Graha Raya Bintaro, making this research increasingly relevant and important to conduct.

In this research, data collection will be conducted through surveys and direct observations at the research location. Surveys will be conducted by administering questionnaires to road users, including two-wheeled and four-wheeled vehicle drivers, to understand their views on the effectiveness of the traffic management integration program. Direct observation will be conducted to collect data on the types of vehicles, times, and locations where the traffic management integration program is implemented. This study uses a random observation method on vehicles passing through for three days on the arterial roads of South Tangerang City. Observations will be made on vehicles passing through Boulevard BSD, Raya Serpong Road, and Graha Raya Bintaro Road. The selected locations are areas with high traffic density and accident-prone points in South Tangerang City. Observations will be made during peak hours, namely from 07:00 to 09:00 AM and from 04:00 to 06:00 PM. During the observation, vehicle speed, type, and time of passing through the location point will be recorded. Data analysis will be conducted using quantitative research methods to identify results that can assess the program's

effectiveness. The analyzed data will be used to develop government and security agencies' recommendations for improving traffic safety and road user comfort in South Tangerang City.

The primary assumption of this research is that combining the efforts of the Military Police and Traffic Police to regulate traffic can lead to a reduction in driving speed on arterial roads in South Tangerang City. This study aims to generate suggestions and insights to enhance traffic management methods, improving road user safety within South Tangerang City.

2. LITERATURE STUDY

The following are some references and literature reviews from previous research that has been systematically and structurally reviewed to support this research in building strong critical thinking.

2.1. Average Speed

Average speed is a quantity that expresses the average speed of an object over a certain period. This concept is very important in physics and is often used to calculate the movement of objects. Average speed is the ratio of an object's total distance to the total time required to cover that distance (Halliday et al., 2020). Average speed is also used for car-following models that consider the average speed of preceding vehicles to influence drivers' behavior in maintaining their speed. This model also considers drivers' memory when following a vehicle before them (Sun et al., 2019).

2.2 Correlation between Speed and Safety Factors in Various Contexts

The higher the speed of a vehicle, the greater its kinetic energy (ITF, 2018). When a collision occurs, the kinetic energy will be converted into other potential or kinetic energy that can cause serious damage to the vehicle and injuries to the driver and passengers. The ideal inelastic collision refers to the understanding that colliding objects will stick together with the same velocity after the collision. All mechanical and kinetic energy within the collision system will be lost. The loss of all kinetic energy will be converted into the internal energy of the system when the collision occurs, such as plastic deformation energy and heat generation (Cao & Luo, 2021). If the passengers use seat belts and the collision is severe, the car sensors will send a frequency signal to deploy the airbags. Seat belts and airbags are installed to reduce the risk of passengers being injured and dying since both safety devices are specifically established to protect passengers from their inertia. Based on Newton's first law, passengers without seat belts will continue to move until an external force is applied, assuming that friction between the passengers and the car seats is ignored. The passengers will be thrown out of the vehicle and experience projectile motion, continuing their motion as projectiles.

2.3. Speed Control

"Vehicle speed management" is an approach that optimizes vehicle speed by utilizing real-time traffic data and vehicle information (IEEE Transactions on Intelligent Transportation Systems 2019). This concept includes using technologies such as sensors and monitoring systems to collect traffic data and adaptive speed control systems and cooperative systems to avoid accidents (Hall, 2022). The theory or reference related to speed control is the physics principle of Newton's law of motion, which states that an object will continue to move at a constant velocity if no force is acting upon it. Therefore, to control the speed of a vehicle, the use of an effective and timely braking system, as well as appropriate transmission gears, is necessary.

2.4. Determinant Variables of Speed

The effectiveness of fixed speed cameras with warning signs in critical areas, such as intersections and school zones, is seen for effective law enforcement. On the other hand, hidden speed cameras that are not visible can have a wider and more preventive effect because drivers do not know the location and timing of camera installations, making it more unexpected. Overall, visible fixed-speed cameras are more suitable for specific parts where law enforcement is crucial, while hidden speed cameras can have a wider impact. Research by Siregar (2018) discusses the effectiveness of enforcing speed limits through several interventions on Indonesian roads. This study used three intervention factors: police presence, rider training, and publicity of rider speed choices on the roadside. The results showed that police presence was the only factor that significantly reduced the average speed of riders and increased compliance. Combining these three factors reduced the average rate by 14% and 10% and improve compliance by 72% and 33% until the end of the test route. As an estimate, this intervention could reduce the number of fatalities by 52% and 33%.

The innovation of speed limit refers to the development of technology and methods that can effectively control the speed of vehicles on the highway. Some of these innovations include the collaboration and integration of law enforcement officers and the development of technological devices in law enforcement to warn drivers to reduce speed to reduce the potential for accidents. These innovations aim to improve road safety and reduce the number of accidents caused by excessive speed. "Military Police Traffic Surveillance Activity and Occurrence of Accidents in Israel" is a study conducted in 1984 on the Traffic Surveillance Activity of the Military Police and the Occurrence of Accidents in Israel (Saudry et al., 1984). The study examines the relationship between military and civilian vehicles or pedestrians involved in accidents in Israel between August 1978 and March 1982. The research shows an inverse correlation between two types of surveillance by the Military Police, namely speed radar monitoring and motorcycle patrols, with accidents resulting in injuries.

The study found that speed monitoring with radar and motorcycle patrols significantly reduces the number of accidents involving military and civilian vehicles or pedestrians. However, military patrol cars circulating do not have a significant impact on preventing accidents.

The study suggests that effective accident prevention methods involve speed monitoring with radar and motorcycle patrols by the Military Police. However, the study has limitations, such as using cross-sectional data and certain biases. Therefore, the results of this study need to be further tested in well-controlled prospective trials to ensure validity.

3. METHODS

3.1. Research Stages

The author selected methods by determining the sample size, observation, and data processing following the principles of good research. The technique used in conducting the survey conducted phases and stages of activities that are sequential and interrelated between the first stage and the next step begins with:

1. Problem Identification
   In this study, the author identified the problem by observing the arterial road and identifying the problem of high driving speed and potential hazards that may occur as a result.
2. Literature Review
   The author compares and contrasts previous research on the effectiveness of military police and traffic police traffic control in reducing driving speed to determine the concepts

and theories related to the research, such as traffic management theory, driving safety, and others.

3. Problem Formulation
   The author decided on the problem to be discussed in this study, namely, "How effective is the integration of military police and traffic police traffic control in reducing driving speed on arterial roads?"
4. Research Objectives
   The author then conducted an experimental study and analyzed the results to evaluate the effectiveness of integrating military police and traffic police traffic control in reducing driving speed on arterial roads.
5. Data Collection
   The author used observation and experimental methods in data collection. The data collected by the researcher were the speed of vehicles before and after traffic control was carried out and data on the number of accidents and traffic violations. Data was also collected through interviews with military police and traffic police officers.
6. Data Analysis
   The author processed and analyzed the data using statistical techniques, such as t-tests, ANOVA, and multiple linear regression, to determine the effectiveness of integrating military police and traffic police traffic control in reducing driving speed on arterial roads.
7. Results and Discussion
   The author will discuss the results of the data analysis to determine the effectiveness of integrating military police and traffic police traffic control in reducing driving speed on arterial roads by comparing research results and discussing practical and theoretical implications for traffic management concepts and driving safety on arterial roads. In addition, the author will discuss the limitations of this study and provide suggestions for future research that is more comprehensive and representative.

3.2. Research Instruments

A speed measuring device that uses the Doppler effect to measure the speed of vehicles and can function in any lighting condition. However, the speed gun must be used with a camera to take a photo as evidence (Hamelmann et al., 2019). Therefore, speed guns are usually used during the day. If used at night, a flashlight is needed for the camera. The flashlight for the speed gun should use infrared illumination with a wavelength of over 750 nm to ensure driver safety. In addition, the flashlight should have high power so that the camera can take photos from about 70 m to 100 m.

Speed or radar guns typically display the measured vehicle speed on the device screen. Some speed guns can also store speed data in their internal memory or transmit speed data to connected devices, such as laptops or tablets. Additionally, some speed guns can display the measurement time and the distance between the speed gun and the vehicle being measured

3.3. Data Analysis

The data evaluation process begins with examining all the collected data, including observation results and document studies, followed by data reduction, data grouping, and data interpretation. To assess the effectiveness of speed camera usage in Boulevard Bintaro Jaya, each vehicle's speed was recorded and recorded, allowing the effectiveness level of the traffic management integration between military police and traffic police in reducing driving speed on arterial roads to be determined. The lower the vehicle's speed following the city's speed limit after passing through

the research zone, the higher the effectiveness of using speed cameras. Conversely, the greater the vehicle's speed that exceeds the predetermined speed limit after passing through the research object, the lower the level of effectiveness. Survey data was collected and analyzed by conducting data validity tests. Data validation was carried out using a survey method by randomly selecting and determining a sample based on the same vehicle identity passing through the two predetermined zones, namely the before and after zones.

4. RESULTS AND DISCUSSION

4.1. Research Time and Location

The research was conducted on the Boulevard Bintaro Jaya in the city of South Tangerang, where the Boulevard Bintaro Jaya road serves as a main artery that connects two access points to the city, namely the Jakarta-Serpong toll road that connects Bintaro and Pondok Indah. The Boulevard Bintaro Jaya road is the central point of the Transit Oriented Development (TOD) concept. It serves as the lifeline for the development of the Bintaro Jaya residential area, connecting residential districts with educational facilities, healthcare facilities, shopping centers, office buildings, business centers, public transportation systems, and of course, two toll roads Viva.co.id. Therefore, the Tangerang city government has designated the Boulevard Bintaro Jaya road as a main artery that meets the criteria for a major road that serves inter-city or intra-city transportation needs and has a high traffic volume. The process started with a pre-test and a post-test. The research location was chosen considering the need for traffic speed data not disturbed by intervention on the road, and the data will be used to compare results. The survey was conducted for two days on March 3 and 4, 2023, between 1 PM and 4 PM, using a direct measurement method of vehicle speed and recording videos and photos using a speed camera within a 50-meter distance before and after the research zone, with the existing speed limit sign of 40 km/h. The researcher will group primary data according to the type of motor vehicle regulated in Article 47 of the Law Number 22 of 2009 concerning Traffic and Road Transportation (LLAJ, 2019). The following are the types of motor vehicles referred to:

1. Motorcycles: two-wheeled motorized vehicles with or without housing, sidecars, or three-wheeled vehicles.
2. Passenger cars: motorized vehicles for transporting people with a maximum of 8 seats or weighing no more than 3,500 kilograms.
3. Buses: motorized vehicles for transporting people with more than eight seats or weighing more than 3,500 kilograms.
4. Cargo vehicles: motorized vehicles used for transporting goods.
5. Special vehicles.

Figure 1 Location of the Research on the Map

Figure 2 Position of the Research

4.2. Data Collection

The data in this research was collected using quantitative methods. Quantitative data is obtained from vehicle speed. Data is obtained through a survey to measure the speed of vehicles before, during, and after the observation. The method used is a pre-test and post-test using a speed camera. Primary data is collected by observing both observation and supporting data. The observation and sample measurement include travel time, zone distance, and distance of Military Police and Traffic Police officer location. The next step is to analyze the vehicle speed data by comparing speed data and calculating the N-score as follows:

$$Average\ Speed = \frac{Total\ Distance\ Traveled}{Total\ Time\ Taken} \qquad \text{..... (1)}$$

In this formula, the total distance traveled is measured in meters or kilometers, while the total time taken to cover the distance is measured in seconds, minutes, or hours.

The formula for Paired Sample T-test is as follows:

$$t = \frac{\bar{X}_D}{s_D/\sqrt{n}} \qquad \text{..... (2)}$$

Where t is the value of the $t - test$ statistic, $\bar{X}_D$ is the mean difference between the paired samples before and after the treatment, between the paired samples before and after the treatment s_D is the standard deviation of the differences between the paired samples and n is the number of pairs of data being compared.

$$t = \frac{\bar{x}_1 - \bar{x}_2}{s \cdot \sqrt{\frac{1}{n_1} + \frac{1}{n_2}}} \qquad \text{..... (3)}$$

where $\bar{x}_1$ is the mean of sample 1, $\bar{x}_2$ is the mean of sample 2, s is the standard deviation of all the samples, n_1 is the sample size of sample 1 and n_2 is the sample size of sample 2.

The Paired Sample T-test method is used to compare the mean difference between two paired samples. These paired samples can be taken from the same subject before and after a treatment or different measurements. For example, in a study on a drug's effectiveness, the subject's condition is measured before and after being given the drug. This test can help determine whether the difference is statistically significant or just happened by chance (Sudjiono, 2010; Ghozali, 2016). The test result is determined based on the significance value (p-value) obtained. If the p-

value is less than alpha (usually 0.05), it can be concluded that there is a significant difference between the two samples. If the p-value is greater than alpha, it can be concluded that there is no significant difference between the two samples. It is an effective method for analyzing correlated data. According to Yu (2022), some commonly used statistical tools that consider the dependence of data are mixed-effects (ME) linear and generalized models, which include t-tests and ANOVA as special cases. However, the value of analyzing correlated data is increasingly recognized in many disciplines, including clinical research, genetics, psychology, and many others. N-gain Score is calculated as follows:

$$N - gain\ Score = \frac{(Posttest - Pretest)}{(Highest\ Possible\ Score - Pretest)} \times 100\% \qquad \ldots\ldots\ldots\ (4)$$

Where post-test means the average score on the post-treatment test, pre-test mean the average score on the pre-treatment test, and the highest possible score means the highest score that can be achieved on the post-treatment test, usually calculated based on the number or difficulty level of the question.

Solikah & Novita (2022) found that the N-gain scores obtained were categorized as moderate to high, indicating an improvement in critical thinking ability. To evaluate the overall critical thinking ability, a paired T-test was conducted.

The N-gain Score method is used to evaluate the effectiveness of a treatment in a one-group pre-test and post-test design. This method yields an N-gain score, indicating the degree of improvement in subjects after receiving the treatment. The N-gain score is calculated based on the difference between the pre-test and post-test scores and then normalized using the score scale used. The N-gain score can range from -1 to 1, where 1 indicates the greatest improvement and a score of -1 indicates the greatest decline. A high N-gain score indicates that the treatment provided effectively improves subjects' performance in a measured area. This method can help identify whether a treatment significantly affects subjects.

In the study, the researcher used a purposive sampling method to select the vehicles that will be the object of the study. Purposive sampling is a non-probability sampling technique where the sample selection is based on certain considerations that are relevant to the research objectives. The researcher selected the sample based on the same characteristics of the vehicles previously so that the difference in driving speed before and after the treatment could be measured. A total of 113 samples were taken from the total population of 784 vehicles (Thomas, 2022).

By using the purposive sampling method, the researcher can select samples that are considered representative to be the object of the study and capture a diversity of views about the object of interest. This technique aims to collect different perspectives ranging from common to extraordinary. The purpose of this technique is to obtain a sample that represents the diversity that exists in the population. The data analysis used a pretest-posttest one-group design, which is a technique to determine the effect before and after treatment (Souisa, 2022).

4.3. Instantaneous Speed Reduction

4.3.1 Recapitulation of spot speed

There are two average speeds compared between the initial speed without speed limit intervention (Pre-test) and the intervention speed (Post-test) based on the police supervisor's notes.

Table 1 Comparison of Mean Speed

No	Average Vehicle Speed	Sample	Km/Hours	
			Pre-test	Post-test
1.	The average speed without the intervention of military police and traffic police.	113	65.7	68.8
2.	The average speed with the intervention of military police and traffic police.	113	61.9	38.7

Based on the data, there was a significant difference in the average speed before and after the traffic control intervention by the Military Police and Traffic Police. During the data collection, the authors placed Military Police and Traffic Police at specific positions along with speed cameras that were not visible to drivers. From the data, it can be concluded that the placement of the Military Police and Traffic Police has reduced the speed of vehicles. The data shows a significant difference in average speed between the pre-test, the speed without speed limit intervention, and the post-test, which is the speed after the intervention. The average speed during the pre-test was 61.90 km/h, while after the intervention of the police supervisors, the average speed decreased to 38.76 km/h. In other words, the average vehicle speed decreased by 37.47%. This indicates that traffic control interventions can reduce vehicle speed and improve road safety.

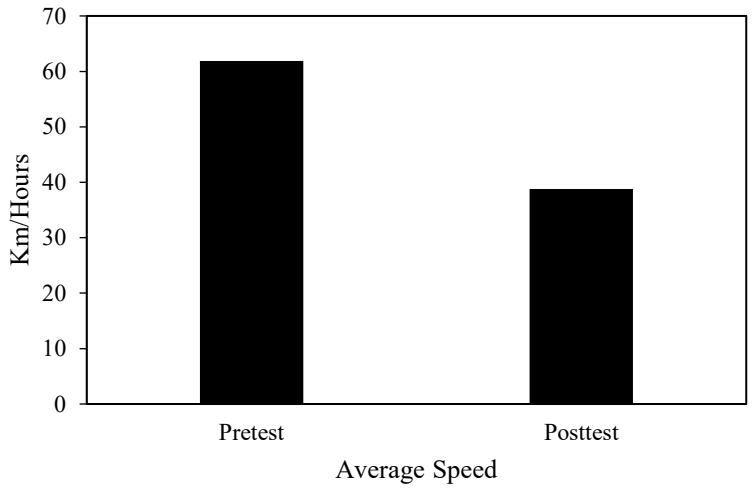

Figure 3 Speed Reduction Graph

From the information provided, it can be concluded that Figure 3 shows a significant change in speed from Zone 1 to Zone 2. If visualized in a graph, there will be a significant speed reduction, especially in zone 2, the control zone. The graph shows that the initial speed of 61.9 km/h in zone 2 decreased to 38.7 km/h after the traffic control intervention by Military Police and Traffic Police was implemented. This indicates that traffic control can effectively reduce vehicle speed in the control zone and improve road safety.

4.3.2 Summary of Average Speeds by Vehicle Type

From the information presented, it can be concluded that the placement of Military Police and Traffic Police officers has successfully reduced the speed of motor vehicle users in zone 2, or the control zone, for passenger cars, trucks, buses, and motorcycles. This is evident from the lower average speed data in Table 2 and the graph showing the decrease in speed in Figure 4.

Furthermore, field observations have shown that most road users have reduced their vehicle speed when passing through Zone 2, which may be due to the visible presence of Military Police and Traffic Police officers. Another reason for the change in road user behavior is the sudden presence

of Military Police and Traffic Police officers, which influences all road users to slow down their vehicles, read, pay attention, and understand the situation. These results indicate that traffic management interventions can effectively change user behavior and improve road safety.

Table 2 Summary of the Average Speeds by Vehicle Type

No.	Vehicle	Total Vehicle	Km/Hours	
			Pre-test	Post Test
1.	Passenger cars	57	61,2	37.6
2.	Buses	13	62.3	39.4
3.	Truck	6	61.5	41.6
4.	Motorcycle	37	62.8	39.8

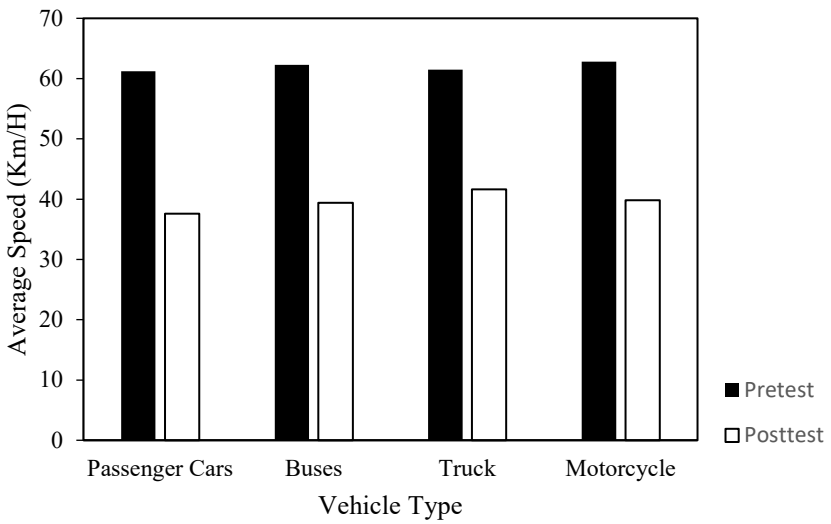

Figure 4 The Comparison of Speeds and Vehicle Types in the Area before and after the Intervention

4.3.3 Effectiveness of Speed Reduction on Arterial Roads

From 113 vehicles passing through zone 2, where the military police and traffic police interventions were installed, 108 vehicles, or 95.58%, have reduced their speed. In comparison, only five vehicles, or 4.42%, have accelerated their speed in the control zone/zone 2. Thus, it can be concluded that the placement of military police and traffic police interventions can significantly affect the speed reduction of vehicles in Zone 2. The percentage of vehicles reducing their speed by 95.58% indicates that the intervention has successfully influenced drivers' behavior to slow down their vehicles in the control zone.

Table 3 The Overall Speed Reduction Data

No	Vehicle	Total Vehicle	Zona 2	
			Deceleration	Acceleration
1.	Passenger cars	57	53	4
2.	Buses	13	13	0
3.	Truck	6	6	0
4.	Motorcycle	37	36	1
	Total	113	108	5

4.3.4 Effectiveness of N-Score

Table 4 Categories of N-Gain Effectiveness Interpretation

Percentage (%)	Estimate
< 40	Not Effective
40 - 50	Less Effective
56 - 75	Moderately Effective
>76	Effective

Source: Widodo, 2016

Table 5 N-Gain Result

No	Type	Sampling	Pre	Post	Post-Pre	Ideal score	N Gain	Conclusion
1.	Passenger cars	57	61	38	- 24	-11	210%	Effective
2.	Motorcycle	37	63	40	-23	-13	180%	Effective
3.	Buses	13	62	39	-23	-12	185%	Effective
4.	Truck	6	62	42	-20	-12	172%	Effective
5.	Overall	117	62	39	-23	-12	194%	Effective

The N-Gain Test found that the average speed after implementing speed signs and supervising police was lower than the average speed before the intervention. This indicates that the vehicle speed before the intervention was higher than after the intervention. Additionally, the N-Gain result exceeded 76%, indicating that the intervention of speed signs and supervising police effectively reduced vehicle speed on the arterial road.

4.3.5 T-Test

Table 6 shows that the t-value for four types of vehicles (car, motorcycle, bus, and truck) exceeds the t-value in the 0.05 table. This finding indicates that the slowing down vehicle speed on the road has complied with the maximum speed limit of 40-50 km/h with a 5% error rate. In other words, traffic regulation carried out by the military police and traffic police has effectively reduced vehicle speed on the road. It is crucial in reducing the risk of traffic accidents often caused by speeding.

Table 6 T-Test with a 5% Error Rate

T-test	Sample	T Count	T Table	Decision	Conclusion
Overall	113	20,76	1,98	Rejecting the null hypothesis	According to Plan
Passenger cars	57	14.75	2,00	Rejecting the null hypothesis	According to Plan
Motorcycle	37	13.30	2,03	Rejecting the null hypothesis	According to Plan
Buses	13	5.42	2,16	Rejecting the null hypothesis	According to Plan
Truck	6	3.95	2,45	Rejecting the null hypothesis	According to Plan

Based on the results of the research and discussions using a 5% error tolerance, several conclusions can be drawn as follows, the average speed on Boulevard Bintaro Jaya road through the placement of Military Police and Traffic Police is 38.7 km/h, which is more effective in

reducing speed compared to the average speed when passing through the Military Police and Traffic Police placement, which is 68.8 km/h. The average spot speed after passing through the Military Police and Traffic Police from north to south is 37.6 km/h for passenger cars, 39.4 km/h for buses, 41.6 km/h for trucks, and 39.8 km/h for motorcycles.

Based on the research results, it was found that 95.58% of the 117 sampled vehicles obeyed the rules to reduce vehicle speed when passing through the location guarded by Military Police and Traffic Police. The number of vehicles that complied with the rules was 108. The presence of traffic police and military police can contribute to reducing driver speed and minimizing traffic accidents. However, the deployment of these authorities on the roads should not be constant, as certain factors need to be considered. Firstly, mapping and analyzing traffic accident data is essential in determining the locations that require the presence of traffic police and military police. This approach can help ensure their effectiveness in reducing traffic accidents. Secondly, available human and financial resources must be considered, as the deployment of traffic police and military police requires significant resources. Thus, it is necessary to assess whether their presence on the roads is proportional to the benefits they provide. By considering these factors, the presence of traffic police and military police can be optimally managed to reduce driver speed and minimize traffic accidents effectively. The analysis of the planned speed limit design in the range of 40-50 km/h in zone 2 found that five vehicles or 4.42% increased their speed beyond the planned speed limit. This shows a mismatch between the expected speed in the design and the speed performed by some drivers.

The effectiveness of speed restriction through the placement of Military Police and Traffic Police has reached the maximum value, as seen from the percentage of speed reduction in Zone 2, which has an effectiveness rate above 50% for all types of vehicles. The research results show that the placement of Military Police and Traffic Police successfully reduced vehicle speed in Zone 2. Although some vehicles do not comply with the planned speed limit, the overall effectiveness rate is still above 50% for all types of vehicles. This indicates that applying speed restriction through the placement of Military Police and Traffic Police can be considered effective in influencing driver behavior and reducing the risk of accidents on the road. However, this system needs continuous evaluation and improvement to achieve its goals more optimally.

5. CONCLUSION

Speed guns are speed control devices current Indonesian traffic police record photos, videos, and the time of vehicles exceeding the maximum speed limit of 50 km/hour. Nevertheless, many vehicles still exceed the maximum speed limit. To address this issue, the active involvement of police officers and law enforcement officials is needed to impose penalties on those who violate the maximum speed limit. This is consistent with the latest guidelines from the World Health Organization (WHO, 2018), which states that law enforcement against speeding violations can help reduce traffic accidents.

Stopping sight distance is useful for determining the reaction distance or distance drivers need to respond and make decisions when facing obstacles ahead (Chen et al., 2019). Stopping sight distance consists of two parts: reaction and braking. The time required for the driver to react and make decisions is called PIEV time (Perception, Identification, Emotion, Volition). PIEV time is influenced by the driver's conditions, including habits, weather, lighting, and mental conditions, and is estimated to take about 1.5 seconds. After the decision to step on the brake, the driver needs about 0.5 to 1 second to step on the brake, and in planning, 1 second is taken. Therefore, the total time required is about 2.5 seconds.

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